«Research to Practice»

Montréal 2012
Management of Construction
RESEARCH to PRACTICE

«Du savoir au Savoir-faire»

Joint CIB International Symposium of W055, W065, W089, W118, TG76, TG78, TG81 and TG84

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Conference Proceedings

Volume 1

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Montreal, Canada

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FOREWORD

Welcome, everyone!

On behalf of the organizing committee for the 2012 CIB International Conference, it gives me great pleasure to welcome you all to Montreal, the largest French-speaking city in the Americas and, more recently, the capital of pots-and-pans street concerts greeting our guests with a unique joyful clanging!

The theme of this conference, Research to Practice, focuses on what is needed to meet the challenges of the ever-evolving building industry.

Societies are resolutely turning to energy efficiency, sustainability and increased harmony between people and their environment. The industry must cope with rapidly changing standards and client needs while being faced with productivity and cost control. Creativity is definitely key to this puzzle, which will be solved through a closer relationship and understanding between research and industry.

The Montreal conference is taking a step in this direction by adding an Industry Day to its program. On Thursday, June 28, participants from all aspects of construction, planning, managing and so on will gather with researchers to hear a distinguished panel of academics and industry experts share and discuss their views on research and the building industry and the importance of the link between the two.

Afternoon sessions will then provide everyone a chance to determine and define the most promising ways to successfully develop and transfer essential knowledge in the building field.

The organizing committee has endeavoured to provide participants with surroundings that will enhance learning and networking activities for Working Commissions W055, W065, W089 and W118.

I wish you all an enlightening conference and a pleasant stay in Montreal.

Serge Boileau

Conference Chair, MCRP 2012

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Leading indicators for forecasting civil engineering market development

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Abstract

Civil engineering has traditionally been a closed market. However, the 21st century has seen it opening up and becoming a new business area for companies. Business knowledge is required in business management, but the availability of that knowledge is scant. It is difficult for companies to plan their future business as they often do not even have knowledge of today's market structure or situation. The public sector also has a need for knowledge, for example when it strives to optimise the timing of individual projects or recovery activities. Private companies and the public sector link civil engineering to the state and the development of the general economy. A multitude of variables is available for the economy. Economists do not comment specifically on the interplay between civil engineering and the economy, i.e. how well these indirect variables depict the overall field. The core purpose of this study was to identify the key variables from this commonly used mass of variables that would in reality predict the short-term development of civil engineering. In the first phase, we studied whether key variables could be identified for the entire field of civil engineering. As this line of study proved unfruitful, in the second phase we divided civil engineering into three client types: local government, central government and the private sector. Going down to the level of market segments proved fruitful, but not to a sufficient degree. The third phase comprised dividing the demand in the business sector into, for example, global and typical domestic manufacturing demand. The research problem is approached within a contextual framework. The interaction is studied in the time dimension, both within the business and at the level of the operating environment. The validity of the variables is studied using statistical methods. The most detailed level of the study focuses on one country where sufficiently long-term time series are available.

Keywords: Leading indicators, Civil engineering, Short-term development

1. Introduction

The civil engineering market has changed from a closed market towards a more open one both in Finland and many other countries since the 1980's. In several final product sectors, investments earlier financed by taxes are being financed by user fees. Actors of this sector have become increasingly international. (Nippala & Petäjä, 2004) Companies operating entirely in the international markets like IT companies have also emerged (Runeson & de Valance, 2009).

Companies and organisations need information on the actual quantitative change in the civil engineering market for both short-term (budgeting) and long-term (strategic) planning of their operations. In a closed market, the plans of the client sector were sufficient as an information source. This source of information has become less valuable because of the change in the markets. New kinds of markets also need new information sources to forecast changes in them.

Civil engineering companies have expanded their operations beyond their traditional market and assumed tasks from other sectors. For example, they are increasingly involved in works traditionally considered new building construction. Site area works and ground improvement are often continued by foundation work. Another area of expansion has been in the direction of the mining industry in the form of participating in both the opening of mines and extraction of minerals. Companies are also interested in forecasting developments in these new business areas.

The rest of the paper is organised as follows. Firstly, we shall deal with the theory and observations on the civil engineering market made at the beginning of this research already discussed at the previous CIB 2011 Conference. Secondly, we shall discuss statistical analyses of the functioning of indicators, and thirdly, we shall look at the present situation and determine the direction of further research.

2. Research objective and theory

The objective of this project is to find indicators to forecast future civil engineering markets. Here, civil engineering refers not only to traditional civil engineering but also to investments in energy supply and telecommunication networks, as well as area works of building construction, maintenance of grounds of properties and some mining operations.

The research uses the contextual research paradigm (Pettigrew, 1990) that focusses on past, present and future internal changes in infrastructure construction and its operating environment. The objective is to find key indicators that can be used to evaluate the present situation of infrastructure construction and forecast the future development of the market.

Economic indicators can be classified into three categories according to their usual timing in relation to the business cycle: leading indicators, lagging indicators, and coincident indicators (Eurostat, 2010).

A leading indicator is an economic statistical indicator that changes before general economic conditions have started to change and can therefore be used to predict turning points in the business cycle. Typical examples of leading indicators are stock prices, business and consumer expectations. In short-term statistics the number of building construction permits is a typical leading indicator.

In this research we search for so-called key indicators among these leading indicators that could forecast economic conditions earlier and more reliably than others. Furthermore, we try to identify those indicators that move in lock step with the markets under study. They are called **coincident indicators.**

A coincident indicator is an economic statistical indicator that moves (more or less) in lock step with the economy and therefore reflects the current status of the economy. Typical examples of coincident indicators are industrial production and turnover. A coincident index may be used to identify, after the fact, the dates of peaks and troughs in the business cycle.

Today we are flooded with information. Therefore, it is important to distinguish the above-mentioned indicators from those that reflect history, lagging indicators. A **lagging indicator** is an economic statistical indicator that changes after macroeconomic conditions have already changed. Typical examples of lagging indicators are unemployment figures, profits or interest rates. In short-term statistics the number of persons employed is a typical lagging indicator. (Eurostat, 2010)

3. Changes and indicators

The research started at the beginning of 2011 with an analysis of changes in history. The infrastructure construction market began to open up around 1990. The development continued until the financial crisis of the late 2000's (Nippala, Tienhaara, 2011). Now people are clearly taking the time to estimate the effects of the development. The privatisation of public services has in some cases brought clear savings. On the other hand, the profits of companies have suffered as they have been competing for markets. Competitive bidding for public services in the infra sector was also problematic at the beginning when several companies appealed to the Market Court about it.

Simultaneously with the opening up of competition, design-build-finance-operate (DBFO) contracts were introduced to Finnish public sector infrastructure projects. That also aroused some criticism. Financing costs are often higher in the private sector than in the public sector and, despite efficient production, often lead to expensive acquisitions. The positive economic impacts of private financed projects are immediately available to society, but limit future contracting markets as the annual payments of private financed contracts implemented earlier must be paid out of the public sector budget.

When the infrastructure market opened up for competition, the market economy entered the picture. Civil engineering started to undergo more economic fluctuations. Monitoring of business cycles started focussing also on the plans of other clients and builders' order stocks and willingness to bid along in addition to public sector budgets. As the size of infrastructure projects grew, extraordinarily big infrastructure projects, such as major ports and big power generation plants were also placed under monitoring. (Nippala, Tienhaara, 2011)

However, forecasting of business cycles on the basis of plans is more like establishing the current situation. Such information was needed, for example, during the financial crisis to decide about the government's stimulus measures. During decision making the infrastructure sector and the government had a heated debate on whether demand in the sector was poor, normal or even overheated. Decisions could not be based on statistical data because the statistics lagged behind the present situation and were even partly contradictory.

New indicators to forecast changes in the civil engineering market volume have been searched from the business cycle forecasts on 19 countries produced by the Euroconstruct network (Nippala, Tienhaara, 2011). They do not link the quantitative development of civil engineering to indicators by mathematical formulas. These are mentioned only as reasons for the economic development without evaluating their effectiveness. The most commonly mentioned indicators include:

- general economic situation
- good/bad economic situation of the public sector
- legal obligations (quality of water/air, waste water treatment, energy consumption)
- political programmes (TEN channels, TEN energy, TEN telecommunications)
- political decisions (Maastricht, free competition, CO2)
- local government elections
- price of oil
- growth of consumption (traffic volumes, energy consumption, water consumption)
- capacity and age of infrastructure.

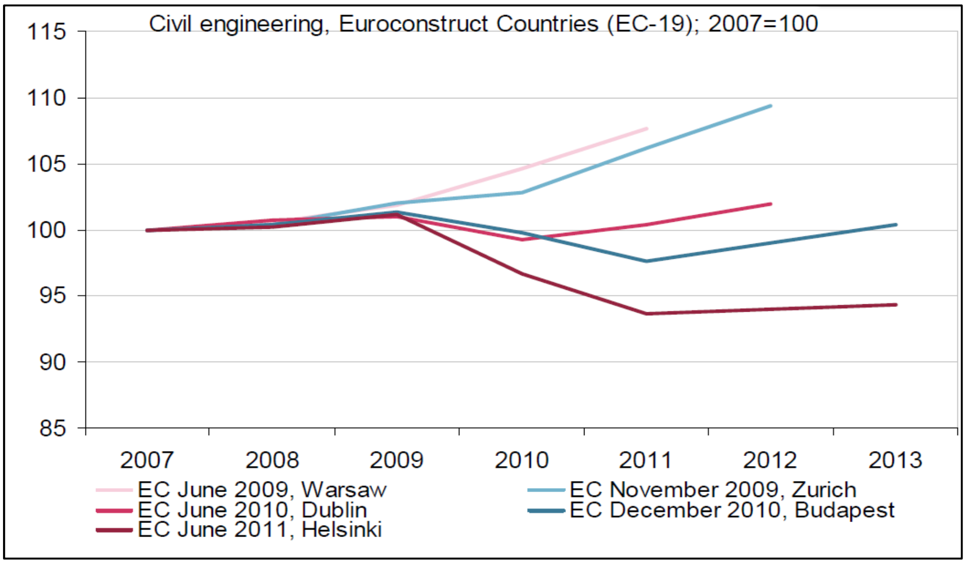

Figure 1. Euroconstruct forecast for the development of the European civil engineering market volume from the summer of 2009 to the summer of 2011. The difficulty of forecasting is shown in the figure as great variations in the forecast.

The forecasting of civil engineering developments on the European level has proven really difficult in recent years. Semi-annual Euroconstruct forecasts from recent years are shown in the figure below (Figure 1). The difference between the forecasts for 2011 is 15 per cent units, ~ 50 billion euros. The realisation was 302 billion euros (Abrahamsen, 2011).

4. Testing indicators

4.1 Test method

The reviewed material consists of two types of data. Total civil engineering market data includes quarter observations from 1970−2010 having a maximum of 160 observations, which limits to 120−140 findings for some variables. The second type of data was examined for submarkets, placed for era 1975−2010 and consisting only yearly data. It holds a maximum of 36 observations per variable. However for some variables, there were only 16−25 observations to be found. The relations of the variables were examined by methods typically used with time series. Because the material consists of annual data, trend removal, proportioning (logarithmic conversion) or differentiation are used to filter the material, as necessary.

Time-series which have constant mean and variance over time are said to be stationary. Stationarity is assumed for achieving reliable conclusions: non-stationary time-series may yield random results. As most of used variables are not stationary but time-dependent they are dealt with trend-removal. (Kendall, Ord 1990)

For yearly data the existence of a trend is dealt with filtering the observed trend. The direction of change may also be other than linear, for example, quadratic and time-dependent, which is why filtering is performed case by case. The quarterly data is processed with differencing to remove seasonal trend and thereby persuade stationarity. (Kendall, Ord 1990) In the analysis of civil engineering or the economy, trend removal refers, for example, to converting current prices to flat rates. The purpose of trend removal is to eliminate the change that takes place in the series in any case, such as recurrent economic fluctuations, to be able to examine their deeper nuances.

Logarithmic conversion is used to normalise the variables, that is, to observe relative changes in the variables. Logarithmic values were used in the comparisons when possible. Because a logarithm can only be taken of a positive number, some variables were defined as a percentage of GDP if they contained also negative values and had originally given in that form in the material. The percentages also indicate relative values.

The variables are compared one at a time against civil engineering. The relation is first examined using graphic descriptors to assess their joint integration. Graphs are also made for trend-filtered variables to get a more accurate result for the dependencies of the directions of variables.

Change balances, i.e., sums of the numbers of changes in the same direction, are calculated for the pairs. This figure may support the correlation, which makes it possible to conclude whether the variables affect directly or inversely each other's changes. If the balance figure were close to half of the number of common events, it could be interpreted to imply that changes between the variables are not closely interconnected. By contrast, if the balance figure is close to the extreme ends (0 or maximum number of observations), it can be assumed that the variables are interrelated directly or through a third variable. For example, if 80% of the changes in variables *a* and *b* are in the same direction, they can be considered to be strongly directly proportional. Should the variables have only 20% changes in the same direction, they would have 80% changes in a different direction, indicating strong inverse proportionality.

Correlations indicate linear dependencies. In the case of time series variables, the correlations calculated for the initial values are rather high for unlimited variables, since time series often have a trend, a direction of development. Thus variables that increase or decrease over time may have significant correlations, as the scatter plots generated from them follow a trend. Filtered variables, again, have had their trend removed, so it is possible to observe similarities previously masked by apparent dependencies. Significant correlations between stationary series are a more reliable indicator of dependence than correlations between the original values.

Time-dimension is important feature in this study. Since correlations are calculated with time-series compared each other, they are placed in comparison with time too. Normally correlations are taken from values that happened on same moment. This will yield only the dependency of concurrent events. By moving the compared value pairs we are able to observe the correlations between lagging and delaying variables. The method is called cross-correlation and it is instrumental in estimating the degree to which two series are correlated. From these correlations it is possible to gain findings from the causality between two series. Are changes taking place at the same time? (Kendall, Ord 1990)

While moving the series in time dimension the amount of compared pairs reduces. This is particular fall for those variables with small observation amount. Thus, the time differences used in this study are relative small (±3 for yearly data, ±8 quarters for quarterly data).

The test results for the cross-correlations are visualised as graphs. The horizontal axis shows the difference between the value of the variable and investments in infrastructure at a given point in time. At zero, the variables represent the same year, at -2 the correlation of the variable is shown 2 years (/quarters) before the infrastructure investments, and +2 shows the reaction of the variable two years(/quarters) after the investments. Only indicators whose correlation exceeds 0.7 at least one year earlier are qualified as key indicators. The values of the curves for the key indicators would appear on the timeline between -1 to -3 years and have a correlation factor of over 0.7, that is, they would show in the top left corner of the graph. Correlations between 0.3−0.7 (from absolute values) are seen more suggestive results.

4.2 Testing of indicators

The first two indicators mentioned by the Euroconstruct network were tested statistically for forecasting the development of Finland's entire civil engineering volume. GDP and investments (machine investments, residential building investments other building construction investments) were used as indicators of the overall economic situation. Public sector consumption was used as an indicator of the state of public finances.

As the first round did not yield a result, the search for indicators was continued in submarkets. The selected submarkets were different types of customer sectors: state administration, local government (municipalities) and companies. All three were examined separately to see which factors could affect investment decisions. Suitable indicators were chosen to represent the factors, and their relation to civil engineering was statistically tested. The following variables or potential key indicators were tested:

State investments:	GDP, tax revenue, government budget deficit, road traffic output, traffic and communication expenses price index, price of oil, earth work costs, unemployment
Municipal investments:	GDP, tax revenue of municipalities, indebtedness of municipalities, local government deficit, building construction, population growth
Private investments:	GDP, inflation, building construction, industrial confidence, world trade, price of oil.

State investments

On the basis of statistical testing, unemployment correlates best with civil engineering. However, the correlation was of the wrong kind. Instead of forecasting, it reacted to changes in civil engineering with a delay of 1 to 2 years. It was thus a so-called lagging indicator. The best indicator for forecasting future volumes of state implemented civil engineering were the plans of the Ministry of Transport and Communications – exactly the same indicator used for forecasting while the market was closed. The rather weak correlation of this indicator is, however, surprising: three years in advance it is 0.5 (Figure 2).

A large part of state-financed civil engineering involves maintenance of existing civil engineering constructions, and the share of new investments is contracting. Economic fluctuations or financial crises do not affect this market segment. Big investments are political decisions made by the government. None of the analysed variables considers this viewpoint.(Figure 2)

Municipal investments

Municipal population growth correlated with the infrastructure investments of municipalities 3 years in advance. However, the correlation coefficient was weak: 0.5. An almost equally good indicator would seem to be the tax revenue of municipalities. It forecast municipal infrastructure construction one year in advance. Even better key indicators were economic development (GDP) and building construction permits. There was a strong correlation of 0.7 to 0.8 between these phenomena.(Figure 3)

Municipalities must build transport connections, water supply and power supply networks and public services such as schools and day-care centres for new focal areas of building. This often takes place simultaneously with building construction. However, building construction permits are applied for well in advance, 1 to 3 years before building starts, and therefore this indicator is indeed good for forecasting future municipal civil engineering volumes.(Figure 3)

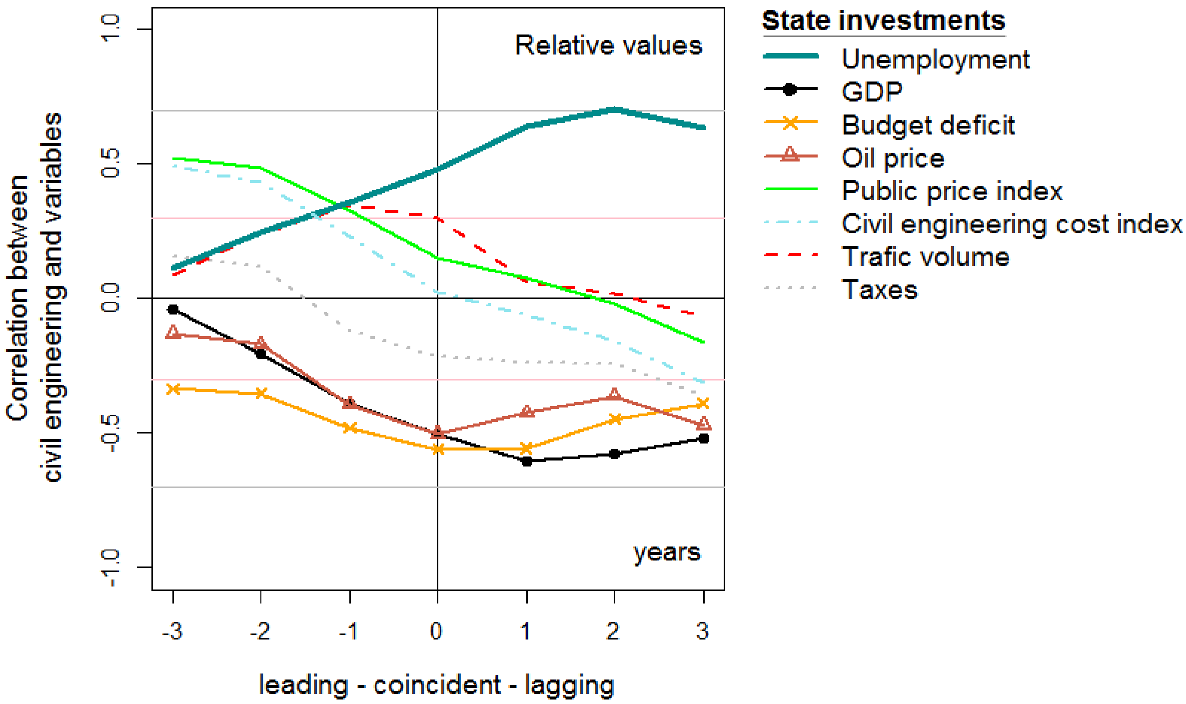

Figure 2. Not a single indicator with a correlation with actual civil engineering exceeding 0.7 was found among the indicators of state-financed civil engineering works. (Sources: see statistical references).

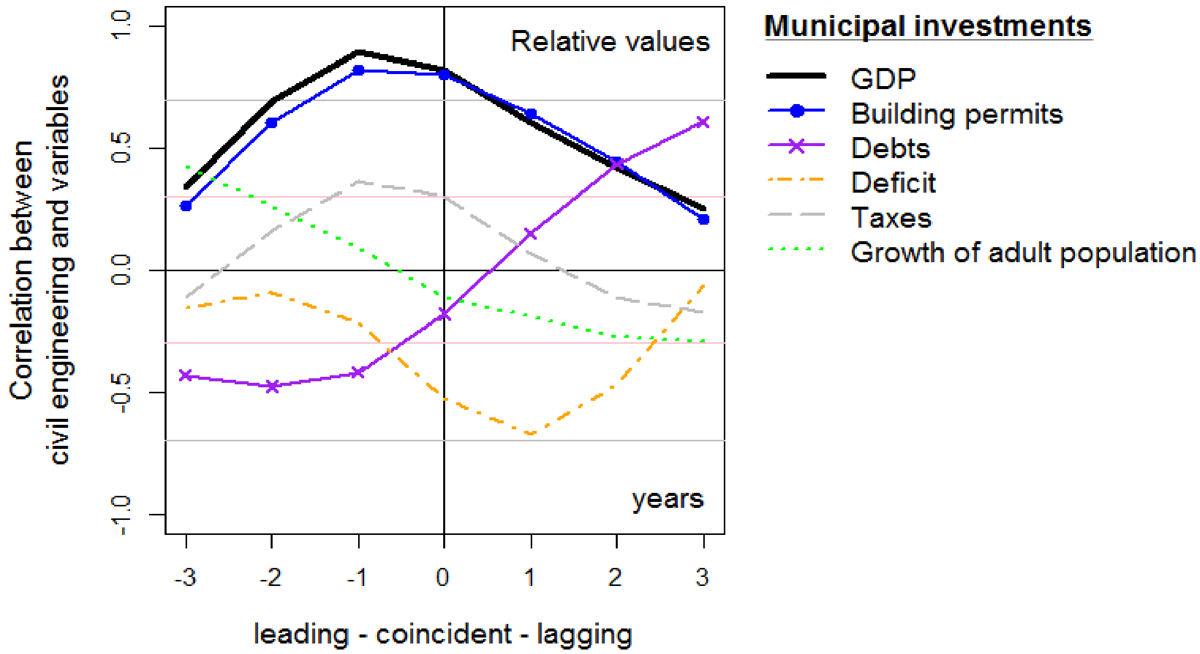

Figure 3. GDP and building construction permits correlate best with municipal civil engineering one year in advance. (Sources: see statistical references).

Private sector investments

Only one key indicator, and two that nearly make the grade, were found for the private sector. Based on correlation, the industrial confidence indicator published by the European Union Statistics Office turned out to be a key indicator. Industrial confidence is inquired on a monthly and quarterly basis. The correlation factor of material published one year in advance is almost 0.8, which is high enough for a key indicator.(Figure 4)

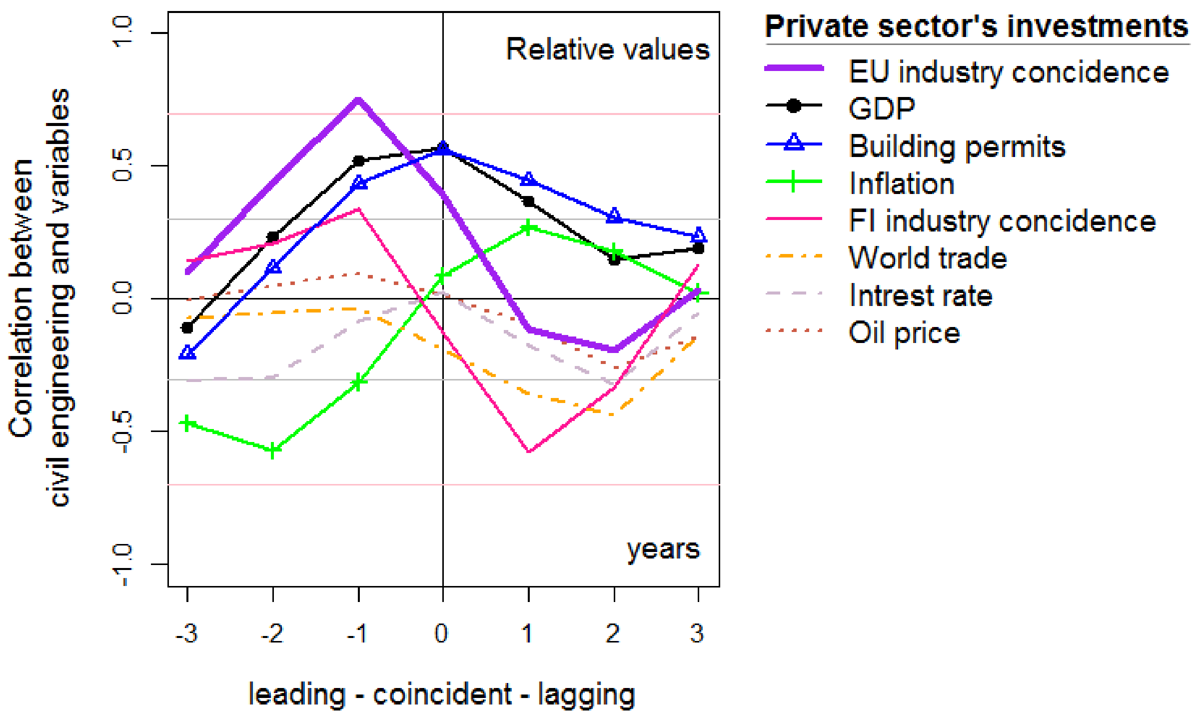

Figure 4. Analysis of private sector key indicators. (Sources: see statistical references).

It is indeed logical that the industry invests when confidence in future is high, and curtails investment when confidence is low. That is also indirectly reflected in industrial civil engineering investments. Many investments include components of machinery and equipment as well as building and civil engineering investments.

5. Discussion

Before 1995 the infrastructure market in Finland was relatively closed. When a public sector contractor had a significant share of the market, the leading indicators were public sector budgets, state subsidies, regional politics and the GDP forecast.

After 1995, the Finnish civil engineering market has largely opened up for competition. Therefore, it is assumed that forecasting indicators have also changed. To find out whether that is true, it was first determined if some variable commonly used on the European level is better than the others in forecasting the development of the civil engineering market. None of the statistically analysed variables correlated strongly enough to earn the status of a key variable.

The reason was thought to be the fact that the subsectors of the civil engineering market follow different logics and may cancel out each other's fluctuations. It is difficult to find common explanatory factors for such a market.

It was decided to run statistical analyses separately for each submarket. Civil engineering was divided into subsectors based on the availability of information. The subsectors were investments in infrastructure by state administration, local government (municipalities) and companies. Separate logical factors affecting decision-making were chosen for each of the three subsectors.

No key indicator was found for the state sector even in the second round of analysis, although investments are seemingly outlined, for example, in the government programme. The researcher's opinion is that decision-making is affected by politics and cannot thus be forecast.

Two key indicators were found for the municipal sector, i.e., GDP and building construction permits as indicators of the economic situation. Municipalities are a post-cyclical sector in relation to general economic development, which makes it easier to forecast their investments. Building construction permits also indicate what happens in civil engineering, that is, the building of street, water supply and power supply networks.

One key indicator was found for the private sector, the industrial confidence index. Economic development also seems to almost deserve that name. The correlation of the industrial confidence indicator with private sector investments is logical. When industry is confident that demand will increase, the threshold for investments is exceeded and investments in civil engineering start.

6. Conclusion

The focus of this paper is on the key indicators for Finnish civil engineering construction. The need to identify key indicators arises from changes in the market structure, which have increased the need and demand for forecasting. People also want to make monitoring and forecasting more effective by excluding irrelevant data.

The findings on the Finnish and European civil engineering markets are quite similar. The most significant differences are the roles of private sector and the time horizon. Even though the Euroconstruct network tries to forecast business cycles, the reports focus on long-term drivers. And even if there is a lot of talk about co-operation between the public and private sectors, the effect of the private sector on changes in the market is not recognised.

No key indicators that could forecast changes in the overall volume of civil engineering in the near future were found. By contrast, analyses by client sectors found a few key indicators, such as European level industrial confidence, as a key indicator for private sector investments, and economic development and building construction as an indicator for municipal investments. Although state investments are outlined already in government programmes, day-to-day politics change plans to the extent that even the plans of the responsible ministry fail to correlate with the investments it finally finances.

The analysis will be continued at least with regard to state and private sector investments. It is also our intention to find an alternative way to break the whole down into submarkets and find key indicators for them. The boundary conditions for this alternative are set by the available input data.

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An empirical analysis of the effects of governmental stimulus programs during the financial crisis of 2007 on the German construction industry

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Abstract

Governmental stimulus programs aim to overcome an economic downturn or crisis through fiscal actions such as investments in particular industries e.g. infrastructure or similar; thus, preserving and creating jobs to stabilize the local or national economy. This paper investigates the effects of stimulus programs in Germany; in particular, those approved by the German government during the financial crisis in 2008 and 2009. It was hoped that with these programs, the construction industry would stimulate the entire German economy. The findings of an empirical study conducted by a regional construction industry association were analyzed. The members of the association were asked to answer questions on if and how the crisis affected them; in addition they could assess the impacts of the stimulus programs considering employment and turnover. The results indicate that almost every second construction company participating in the survey was affected negatively by the financial crisis. Furthermore, almost every third construction company was able to profit from the German government's stimulus programs. These results combined with a review of the statistical data throughout this period provide a first insight into the effectiveness of the German stimulus programs for construction companies.

Keywords: construction industry, stimulus programs, Germany

1. Introduction

Investing one billion Euros in the transportation industry creates or saves about 25,000 jobs (Bundesministerium der Finanzen, 2011). Therefore, as response to the financial and economic crisis of 2007, which marked the largest economic crisis in the post-war period, Germany took action to stabilize the economy. Following the Keynesian theory that in times of an economic crisis governmental expenditure programs should have a positive direct and indirect impact on the economy, a public stimulus program was started.

The following questions shall be answered in this paper: did the German stimulus program have a positive effect in terms of employment and capacity on the construction industry and did the industry increase its capacities too much in connection with the programs?

2. Germany's stimulus programs

The first of two programs was launched in November 2008 followed by the so called stimulus program II in January 2009, having a total sum of about 100 billion Euros, which is equivalent to an average of 2 % of the GDP per year (for the years 2009 and 2010). About one third of this sum was invested in construction-relevant sectors. These promoted areas are listed in Table 1.

Table 1: construction-relevant measures of the two stimulus programs

	2009	***2010***	***2011***	***Total***
	[billions of Euros]			
Stimulus package I				
transport investment	*1.0*	*1.0*		*2.0*
highways				*1.0*
railways				*0.6*
waterways				*0.4*
support of economically underdeveloped regions[1]	*1.5*	*1.5*		*3.0*
energy efficiency of companies[1]	*1.0*			*1.0*
CO_2 building modernization/restoration[1]	*1.0*	*1.0*	*1.0*	*3.0*
Increase of deductable maximum for household-related services[2]	*0.9*	*0.9*	*0.9*	*2.7*
regional economic structure	*0.2*			*0.2*
Total				***11.9***
Stimulus package II				
transport investment	*1.0*	*1.0*		*2.0*
highways				*0.9*
railways				*0.7*

waterways				*0.4*
combined traffic				*0.1*
Restoration of state property	*0.4*	*0.4*		*0.8*
*Zukunftsinvestitionsgesetz (ZuInvG)**	*6.7*	*6.7*		*13.3*
educational infrastructure				*6.5*
communal infrastructure				*3.5*
Total				***16.1***
Stimulus programs of the states (=Länder)[3]	*1.5*	*1.5*		*3.0*
Overall Total				***31.0***

[1]government grant; public investment volume is higher
[2]estimated tax deficit
[3]partialy scheduled for a longer term as stated in this table
**"Law of investment for the future": 25 % of the total invested sum for investments in infrastructure for education was provided by the states (=Länder) and local authorities. The total sum amounts to 13.3 billion Euros.*
Source: Gornig, Hagedorn (2010) p. 5

Apart from the investments in infrastructure and other construction-related areas, the stimulus programs also included tax incentives e. g. for new cars and income tax, reductions in health contributions and prolongation of the short-time compensation regulation as employment-stabilization.

3. The German Construction Industry

The construction industry is considered as one of the most important economic sectors in Germany with a construction investment quota to the GDP of 9 to 10 % (Hauptverband der deutschen Bauindustrie e.V., 2011). The industry is classified according to the European NACE standard; yet it is divided into the main construction industry (= "Bauhauptgewerbe", covering all companies who are engaged in construction of buildings and civil engineering) and the finishing trades (= "Ausbaugewerbe", covering all companies concerned with Electrical, plumbing and other construction installation activities, building completion and pure finishing).

3.1 Statistical data for the German construction industry

The statistical data of German construction companies is divided into these two groups too. Moreover, most of the collected data only accounts for companies, which have twenty or more employees. However the industry is very fragmented, consisting of about 320,000 companies (approx. 74,000 in the main construction industry and approx. 246,000 in finishing trades) and nearly 90 % of those fail to reach said benchmark of twenty or more employees. Besides, more detailed data is available for companies of the main construction industry.

In total, close to two million persons (approx. 715,000 in main construction industry and approx. 1,123,000 in finishing trade) are employed in the industry and account for a total revenue of about 185 billion Euros in 2009. The calculation of another indicator, the construction volume, shows that significantly more jobs are affected by this industry due to cross-border spillovers, as it not only incorporates the execution of construction work but also related services e. g. architects, material suppliers and more. Therefore total construction volume in 2010 was calculated to be close to 290 billion Euros at current prices (equals approx. 11 % of the year's GDP) (BMVBS, 2011).

3.2 The region under investigation: Saxony

Saxony is a federal state in the eastern part of Germany (former DDR). It has about 4.1 million inhabitants on an area of 18,400 square kilometers. This makes Saxony one of the smaller states in Germany. It shares borders with the Czech Republic in the South and Poland in the East. Furthermore, it has inland boarders with Bavaria, Thuringia, Brandenburg and Saxony-Anhalt. Its GDP is close to 95 billion Euros in 2010 (Statistisches Landesamt des Freistaates Sachsen, 2012).

The construction sector in Saxony consists of over 26,000 taxable companies with close to 100,000 employees (annual turnover: approx. 1 billion Euros). More than 6,000 companies are part of the main construction industry with about 57,000 employees. However, only over 500 companies have more than 20 employees which demonstrates the fragmentation of the industry. (Statistisches Landesamt des Freistaates Sachsen, 2012b and 2012c)

4. The empirical study

The empirical data for this study was obtained in cooperation with the Saxon construction industry association (named Bauindustrieverband Sachsen/Sachsen-Anhalt e.V. [BISA]). It is a trade and employer's association for companies engaged in the main construction industry in Saxony and Saxony-Anhalt. As a lobbyist for the industry, it performs surveys among their members every six months to capture the actual situation for construction companies within the local markets.

About 100 main construction industry companies in Saxony are organized in the association BISA, generating an annual turnover of more than 6 billion Euros. Nearly half of this turnover is generated in commercial construction, followed by the public and domestic construction (BISA, 2012). As many as 42 % of the companies participate in those regular surveys. More than two-thirds of them are engaged mainly in public construction. Others declared themselves as being engaged in commercial or residential construction.

Four surveys (May 2009, November 2009, May 2010, November 2011) dealt with questions about the economic crisis of 2007 and the effects of the stimulus programs implemented by the German government. The participants were asked to answer questions out of several given choices.

The results of the surveys showed that 54 % of all participating companies were not affected by the crisis, 42 % however were struck by it (surveys of May and November 2009). The most representative answers can be drawn from the group of companies who are engaged primarily or amongst others in the public construction sector as those companies constituted the vast majority. Due to this situation, the research focuses this particular group of companies. Within the group a further differentiation by turnover was done, grouping the companies by turnovers of less than five million, five to twenty million or more than twenty million Euros per year.

The question whether the companies were able to benefit from the stimulus programs was raised in two surveys (November 2009 and May 2010). While earlier within the crisis, the companies engaged in the public construction sector were rather negative in their assessment of the stimulus programs, the later survey in 2010 showed more positive appraisal (see Table 2).

Table 2: Answers to the question: "Was your company able to benefit from the stimulus programs?"

	No benefit from stimulus programs	*Benefit from stimulus programs*
November 2009	*72 %*	*28 %*
May 2010	*59 %*	*41 %*
Weighted average	*65.5 %*	*34.5 %*

Nevertheless, most companies (65.5 %) did not see any benefit from the stimulus packages of the German government. In terms of turnover, it cannot be determined if companies with a rather small or high turnover profited more from the stimulus programs than others. The November survey showed a slight trend towards a higher benefit of mid-sized companies with a turnover of 5 to 20 million Euros (approx. 67 % of the companies stating that they were able to benefit from the programs were ranked in this turnover category), but the May survey relativized these findings. The results there did not show a clear trend towards any of the groups.

A question in the November 2011 survey was raised about the effect of the stimulus programs on the capacity of the companies. Given answers included: the company was able to increase capacities, the company did not have to cut capacities or the company was not affected by the stimulus programs.

Table 3: Answers to the question: "How did the stimulus programs affect your capacities?"

	Company increased capacities	*Company did not cut capacities*	*Company was not affected*
November 2011	*10 %*	*50 %*	*40 %*

Table 3 shows the results of the question given by the participating companies engaged in the public sector. In contrast to the answers that were given in the other surveys asking about possible benefits for the companies from the stimulus programs, this result is rather positive. 60 % of the companies did not have to cut capacities or they were even able to increase capacities due to the fiscal stimulus. In contrast, 40 % of the companies did not experience an effect of the stimulus programs on their capacities.

Taking the turnover of the companies into account, it can be concluded that the companies with higher turnovers of more than five million Euros per year had a larger positive impact on their capacities than the others. More than 65 % of these companies were able to increase or not cut their capacities whilst only 38 % of the companies with smaller turnovers were able to not make cuts. None of these participants stated an increase in capacities. Reasons for this can be found in the nature of small companies as they often do not have the capacities to serve the public demand alone. Moreover, the initial costs for bidding are too high for them. Additionally, many of them do not have the experience in bidding for public projects. Thus they participate quite often only as subcontractors and are not affected directly by stimulus programs.

4.1 Conclusion of the empirical study

The findings of the empirical study give an insight into the effects of the German stimulus programs on Saxon construction companies, which are mainly engaged in public construction. Compared to the overall number of construction companies in Saxony, the survey could only represent a small number of them. Nevertheless, a good picture could be drawn from the members of the Bauindustrieverband Sachsen/Sachsen-Anhalt e.V. as the participation in the surveys was considerably high.

Nearly half of the companies polled in 2009 stated not to be affected by the crisis. This finding could be due to the shifted economic cycle of the construction industry in comparison with the overall economy (Grebler and Burns 1985 for example). Yet as the considered companies are mainly engaged in public construction, possibly the crisis did not strike them as much as other sectors (e.g. residential construction).

65.5 % of the companies were not able to profit from the stimulus programs, 34.5 % did experience a benefit. It was found that the number of companies benefitting from the programs increased from 2009 to 2010. This could be due to the time lag between the date of announcement and the commencement of the specific projects initiated by the stimulus programs. As the second stimulus program was only launched in January 2009, the implementation required some time. Only the prolongation of the short-time compensation regulation had an immediate effect. In general, the results could not be linked to the turnover of the companies.

The capacities of the companies were also influenced by the stimulus programs. In the November 2011 survey, the majority of the companies did not have to decrease their capacities (50 %) or were even able to extend those (10 %). The remaining companies were not affected by the stimulus programs. Here, the quantity of turnover seemed to play a role as companies with turnovers of over five million Euros per year rather benefitted from the programs.

Overall, the Saxon construction companies gave a rather positive response of the stimulus programs. Although it did not only help more than one third of the companies to overcome the crisis, it allowed capacity increases for every tenth company. Within the free text areas on the surveys, the companies complained about the slow implementation and a lack of promotion for other sectors like the residential construction. As not all of the money from the programs was spent until the scheduled end of 2010, the programs impacted the construction industry in 2011 as well.

4.2 The overall statistical data

Official statistics provide a quantitative picture of the situation on the market. In this paper, they are used to relativize and compare the findings of the conducted surveys with the overall official situation.

The effects of the stimulus programs can also be evaluated by the number of insolvencies during the time of the crisis. Figure 1 shows the development of the number of insolvencies in the main construction industry in Saxony from 2005 to 2011. The black line indicates the six-month moving average. Apart from an increase of the number in 2009, the insolvencies did not show any particular effects influenced by the crisis. Compared with the numbers of 2005, the situation for construction companies seemed to have improved instead. The average number of insolvencies is more than half size in 2010 compared to 2005.

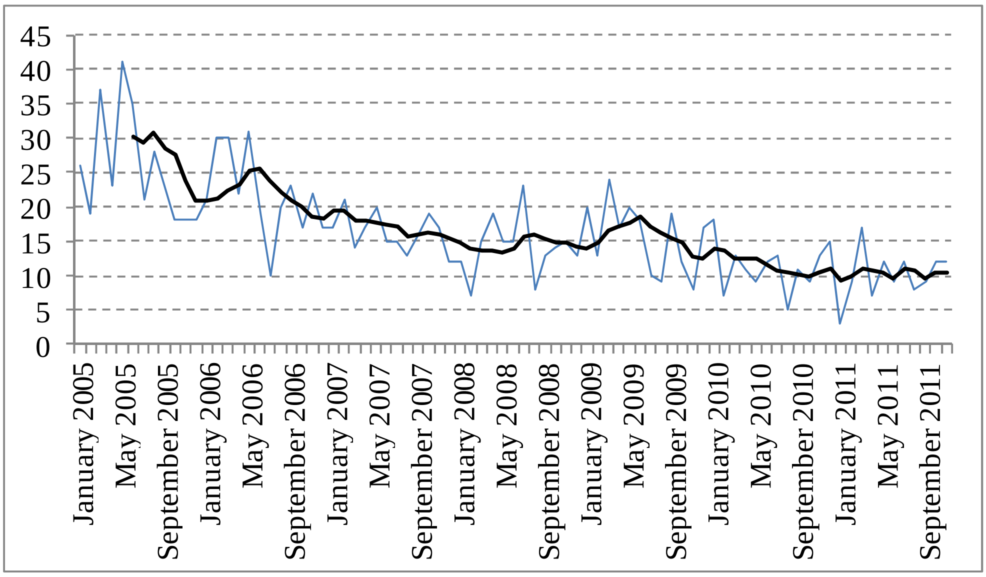

Figure 1: *Insolvencies of the main construction industry in Saxony (Statistisches Bundesamt, 2012)*

This seems surprising. It may be influenced by the stimulus program but also due to the convergence of capacities in the Eastern states (= new Länder) compared to the average in the old states (= old West German states) after the building boom following the German reunification.

Similar to the insolvencies, the number of unemployed construction workers in the main construction industry in Saxony shows a resembling trend with less unemployed workers in the years after 2005. The total number of companies engaged in the Saxon main construction industry has not increased between 2007 and 2009 (see Figure 2). Taken this and the low number of insolvencies into account, it can be concluded that only very few companies entered the market during the years of the crisis.

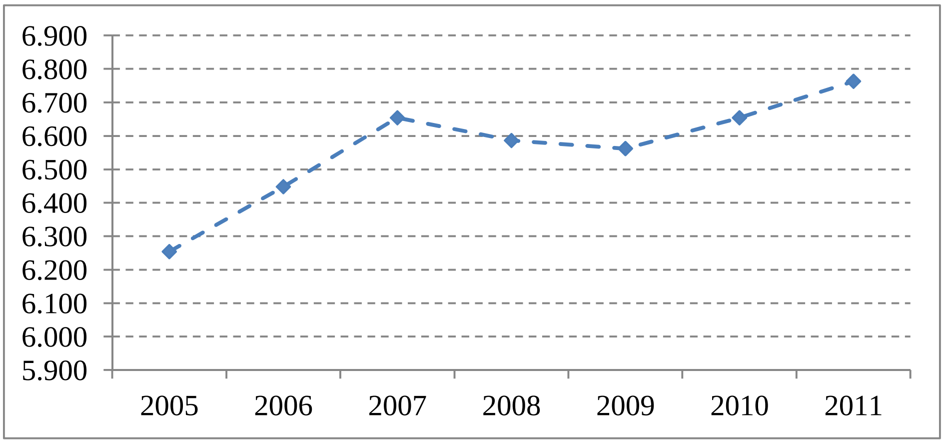

Figure 2: *Total number of Saxon companies of the main construction industry*

The development of an industry during a crisis can also be described by the development of the prices for its products (see Figure 3).

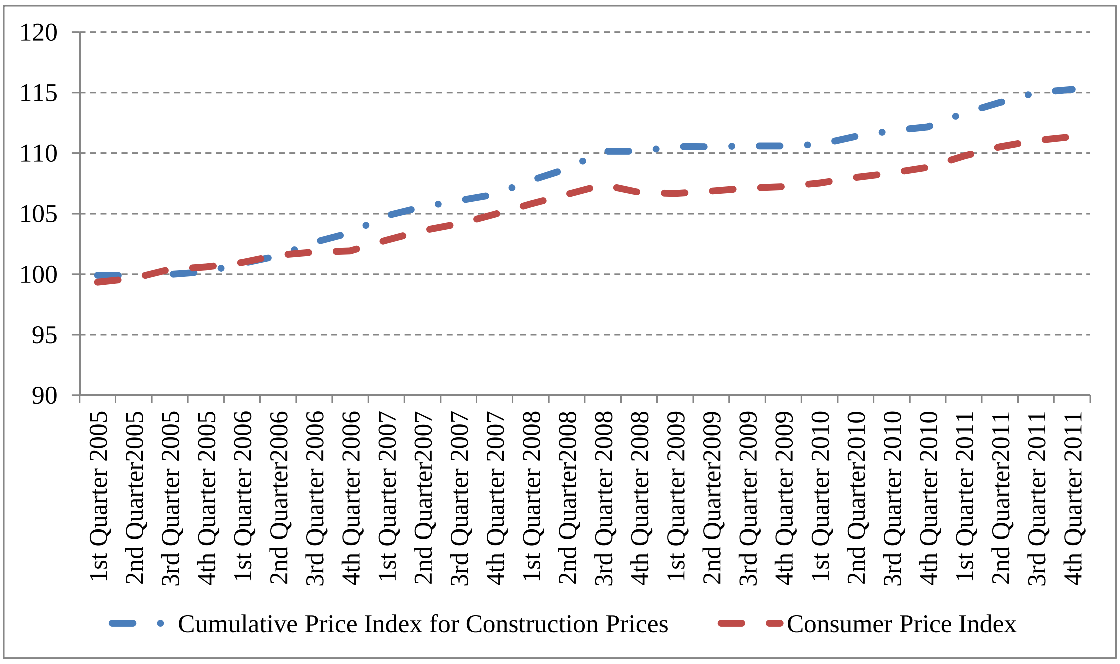

Figure 3 *Comparison of the Cumulative Construction Price Index and the Consumer Price Index in Germany (Statistisches Bundesamt, 2012a and 2012b)*

An upward trend for the German construction price index (cumulative over several different construction price indexes) can be seen from the graph indicating that the stimulus programs triggered by the crisis have led to stable (2008 to 2009) and rising prices (after 2009). Compared to the consumer price index which is the central indicator for evaluation of the monetary value, the construction price index shows a similar trend within the period of the crisis. There is no drop in the construction price index in 2008 contrary to the consumer price index implying that the prices within the construction industry did not experience strong negative effects. As not all impacts on these indicators (e.g. time lag) can be reviewed, further econometric research should investigate these interrelations.

Overall, the statistical data shows that the actual impact of the economic crisis of 2007 on the Saxon main construction industry was comparatively small as it was cushioned by the stimulus programs. Just a small peak in insolvencies and a slightly decreasing number of companies from 2007 to 2009 are due to the economic downturn.

5. Conclusion

With the goal of providing a boost to the economy, the German government implemented two stimulus programs in 2008 and 2009 to fight the financial and economic crisis of 2007. The extent to which the stimulus programs affected the economy, in particular the main construction industry in the German federal state Saxony, was investigated empirically in this paper.

One third of the sum of the stimulus programs was invested in construction relevant sectors. Member companies of the Saxon construction industry association (Bauindustrieverband Sachsen/Sachsen-Anhalt e.V.) evaluated their current situation and the effects of the stimulus programs on their company in four surveys from May 2009 to November 2011. 42 % of the companies were affected by the crisis, more than one third of the companies engaged mainly in public construction stated benefits from the fiscal stimulus. Larger positive effects were experienced in 2010. In the latest survey from November 2011, 60 % of the companies declared their capacities of being stable (50 %) or increasing (10 %) through the stimulus packages.

Linking the results of the surveys to the turnover of the companies showed no significant results. Only the positive effects on the capacities seemed to be true for companies with a turnover greater than five million Euros per year. As smaller companies act mainly as subcontractors, they are not effected directly by the stimulus programs. In total, the stimulus programs did not increase the overall capacities too much. A misallocation cannot be detected through this empirical investigation.

Comparing the empirical results with the overall statistical data gives a similar picture. Being cushioned by the stimulus programs, the financial and economic crisis did not strike the construction industry severely (e.g. no drastic increase in insolvencies). They had a rather positive impact on the companies. Yet, not only the construction industry itself was able to benefit from them, other industries were positively effected through spillover effects as well. This should be analysed through more sophisticated econometric methods as well as by input-output analysis in order to find out the real amount of the direct and indirect demand expenditure of the states. Moreover, the timing of the stimulus programs should be considered critically as the positive effects from the stimulus were experienced in 2010, having a procyclical impact as they came simultaneously with the economic recovery that began that year.

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A Comparative Analysis of Construction Industry International Performance between China and United States Using the International Advanced Index

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Abstract

The double-dip recession in the United States and the debt crisis in Europe have provided opportunities for international contractors in developing countries. The rise in construction activity in developing countries has caused an increase in competition in the global market. The Chinese construction industry has undergone a dramatic change caused by their internationalization strategy in recent years. Significant achievements have been made by the Chinese construction industry. This paper compares the Chinese and United States' construction industries based on the International Advanced Index which was a new measure generated to address problems identified with current measures in the literature. IAI measures the international performance of a country's construction industry by adopting the Depth Index (revenue composition), Height Index (top enterprises) and Width Index (fields involved). The key finding is although achievements have been gained by the Chinese construction industry in recent years, the gap in performance in comparison with the United States' construction industry is increasing. The implication of this result is that the current development strategy of the Chinese construction industry in the international market is problematic.

Keywords: International Advanced Index, Comparative Research, Chinese Construction Industry, U.S. Construction Industry

1. Introduction

The global construction market has been enduring difficult economic problems during the past four years. However, even as the United States continues to stave off the prospect of a double-dip recession and European nations are suffering the debt crisis, opportunities are emerging for international contractors in developing countries, particularly those rich in resources. At the same time, the rise of construction activity in developing countries has caused an increase in competition in global market.

The Chinese construction industry has undergone a dramatic change caused by internationalisation in recent years. In the last 10 years, the Chinese construction industry has made remarkable achievements, through gradually opening up and becoming integrated into the international construction market.

Although the Chinese construction industry has exhibited significant activity in the international market in the last decade following the entry into the World Trade Organization (WTO), in comparison with developed countries there are also some serious problems. There is much rhetoric on achievements, however there has been little research that makes comparisons between various countries.

This paper will firstly discuss the trend of the international construction market and the new features of the Chinese construction industry. A literature review on performance measures has been comprehensively conducted and reported in previous papers (Loncan & Nique, 2010, etc.), however, a brief summary of the key issues is provided in this paper. Because of the problems of measurements which have been highlighted in previous research, the International Advanced Index was introduced to measure the international performance of the United States and Chinese construction industry. The International Advanced Index generated by Zhang and London (2010) is used for measuring the international performance of a country's construction industry by adopting the Depth Index (revenue composition), Height Index (top enterprises) and Width Index (fields involved). Comparative research methodology is adopted to study the differences between the US and Chinese construction industry's international performance. The results of the comparisons between the two countries will then be discussed and implications of the findings are considered for policy makers and construction organisation senior executives.

2. International construction market and Chinese construction industry

Due to the instability of the global economy, the international construction market has been continuously marginally shrinking in recent years. The global shift in the international construction market can be seen in the results of Engineering News Report (ENR)'s Top 225 International Contractors list. The Top 225 as a group generated$383.66 billion in 2010 contracting revenue from projects outside their home countries, which is slightly lower than 2008's figure of $390 billion (Reina & Tulacz, 2011).

Contractors are shifting their focus to new and emerging markets, which can be seen in the Top 225's regional revenue breakdowns. International revenue fell 6.6% to $94.18 billion in Europe. It also fell 6.6% in the Middle East to $72.43 billion and 6.5% to $32.61 billion in the U.S. By contrast, international contracting revenue rose 25.6% to $34.05 billion in Latin America and in the Caribbean, 6.7% to $60.59 billion in Africa and 4.7% to $76.64billion in Asia and Australia. This shift in focus is leading to upheaval for major international contractors (Reina & Tulacz, 2011). The shift could be caused by the mining sectors in these countries and the associated infrastructure required.

Chinese contractors "are becoming bigger competitors," according to Yves Gabriel, CEO of Bouygues Construction, "We are mainly competing [with Chinese contractors] in Africa for the moment, but these companies might probably come in Europe in the future". Chinese construction enterprises have accounted for 51 among the world's top 225 international constructors. The total international revenue of these 51 Chinese construction enterprises is more than $57 billion, which is 14.9% of the total international revenue of the Top 225 (Reina & Tulacz, 2011). The Chinese construction industry's achievements need to be considered in terms of its internationalisation strategy.

Historically, prior to 1979 the internationalisation of Chinese construction enterprises originated from the Chinese Government's Economic and Technical Aid programs. These activities always provided financial donations to other developing countries and this was mainly for political purposes. During this period, Chinese construction enterprises were typically involved in financial aid projects in some developing countries with funds provided by China. However, project funding originated from the Chinese government during this period and therefore Chinese construction enterprises did not participate in any decision-making activities. As a result of the government leadership approach in decision-making the internationalisation of these enterprises can be considered to be passive (Low and Jiang, 2003). However, the Chinese construction industry still accumulated some experience and a pool of talent was trained for the future internationalisation of Chinese construction enterprises. The real internationalisation of enterprises started when the implementation of China's reform and opening-up policy began in the 1980's. Since their entry into the World Trade Organization (WTO), the internationalisation of the Chinese construction industry has moved into a new era. Along with the Chinese construction enterprises' emergence into the international market changes have occurred in relation to their size, financial advantages and the Government's support. In the last 10 years, after entry into the WTO, the Chinese construction industry has made achievements in economic growth, employment and technological advancements and these are now considered.

Firstly, the Chinese construction market is extremely large and growth has been rapid. By 2007, the Gross Output Value (GOV) of the Chinese construction industry has been over$806 billion (NBSC, 2008). After the accession to WTO in 2001, the annual growth rate of the GOV increased significantly, from 10% to more than 20% (Zhang & London, 2010).

Next, the Chinese construction industry provides a diverse range of jobs and offers many new opportunities. By the end of 2007, there were more than 33 million people working in the Chinese construction industry (NBSC, 2008). Prior to joining the WTO employment rates in the Chinese construction industry was in a decline. Specifically, after joining the WTO the employment numbers in the Chinese construction industry increased by 6% every year, except in 2004 (Zhang & London, 2010).The growth could be caused by the “going out” (internationalisation) support strategy whereby the Chinese government provides some tax and financial support to the enterprises involved in the international market.

In addition, the level of technology has continuously improved. The level of technology is mainly reflected in the Value of Machines per Laborer (VML) measure. The VML has increased from $747/Person in 1997 to $1455/Person in 2007 (Zhang & London, 2010).

There are macroeconomic indicators which provide insights on the impact of joining the WTO, and there are also indicators and trends in relation to industry organization economics. The classification of firms in the Chinese construction industry has changed from three categories (State Owned Enterprises, Urban and Rural Collectives and Rural Construction Teams) to five categories: State Owned Enterprises, Collective Owned Enterprises, Private Owned Enterprises, Enterprises Funded by Hong Kong, Macao and Taiwan, and Foreign Founded Enterprises. The trends are:

- State Owned Enterprises and Collective Owned Enterprises show a clear trend of contraction, and their dominance declines correspondingly as expected. The number of firms has been reduced from more than 9600to 5300and the proportion of the total number of Construction Enterprises has been reduced from 22%to 10% (Zhang & London, 2010).

- Private Owned Enterprises are growing rapidly and becoming the main force in the industry. The number of firms increased from 3500 in 1997 to nearly 50000 in 2007 and GOV increased from$8.5 billion to $585 billion (Zhang & London, 2010). This increase is mainly benefited from the development of private economy.

- Enterprises Founded by Hong Kong, Macao and Taiwan and Foreign Funded Enterprises did not increase rapidly in the beginning after China joined the WTO. An explanation for this could be that the first five years after entering WTO, there was a protection stage for the Chinese construction industry. After this stage ended in 2006, there still was no significant change. It is difficult to speculate on the reason for this lack of change in this category and would require further research.

Finally, the organisational structure of the Chinese construction industry has changed after joining the WTO. In order to adapt to the new international environment and industry competitiveness, the Chinese government in 2001 introduced the "construction enterprise qualification grades standards". After its implementation in 2002, the Chinese construction industry initially formed a structured system, which composed of the general contractors, professional contractors and labour subcontractors. General contractors dominate the market. However, both the number of firms and the Gross Output Value of professional contractors and labour subcontractors are increased gradually.

The Chinese construction industry has changed dramatically in the last decade in terms of classification of firms and organisational structure. The market volume, employment and level of technology have also changed in the last decade. The Chinese construction industry has also improved dramatically in relation to international performance. This raises another question regarding international performance: How does the performance of the China construction sector as a developing country compare with that of the US a developed country?

3. International Advanced Index

Two types of measurements are commonly used in the discussion concerning performance, development level or position in the world. The first type is called the one-dimensional financial measurement. For example, GDP and GNP are typically used to measure a country's development level, performance and position in the world. At the industry or firm level, the measurement is related to financial issues, such as total revenue, international revenue, Return on Assets and Return on Sale (Loncan & Nique, 2010). It has been highlighted that this type of one-dimensional measurement doesn't reflect all facets of performance and could lead to misunderstandings (Sullivan, 1996).

The other measurement we propose is called a complex multi-dimensional measurement method. This method is used for comparison between countries by various researchers whereby all the aspects separately. It is a good comparison strategy to find the gap and difference in each element, and hence to generate an appropriate refined development strategy that targets the particular weakness in the current strategy (Wei & Han, 2002). However, this complex comparison doesn't currently quantitatively measure all the elements and indicators that are discussed in the literature (Wei & Han, 2002).In addition, this kind of measurement is commonly generated based on one or two countries' situation and data availability. Therefore it is difficult to be used internationally (Wei & Han, 2002).Consequently an alternative measurement method for a certain country's construction industry's performance and position in the international market has been proposed (Zhang and London, 2010).This method of measurement is based on a quantitative approach and can be used internationally.

Zhang and London (2010) generated a multidimensional quantitative measurement model called the International Advanced Index, according to the characteristics of the construction industry. The International Advanced Index (IAI) is a quantitative measure and index system which intuitively reflects the performance and position of certain country's construction industry in the international market. The International Advanced Index for construction industry is proposed through the following index:

- Depth Index (DI): is defined as the ratio of overall international revenue of all companies of the country to total international revenue of all the companies of all the countries.

- Height Index (HI): is defined as the quantity and quality of a certain country's top enterprises. It is measured in the ratio of the number of a certain country's enterprises in the top international constructors list, which is only the quantity issue. In order to consider the quality issue, a "weight" index is considered, which also reflects the distinction between the different rankings in the top list.

- Width Index (WI): is defined as a certain country's enterprises' market involvement in different specialized fields of the construction industry. It is measured in terms of the average of the ratio of the number of specialized fields that a certain country's each construction firm is involved with to the total number of specialized fields within the construction industry. However, specialization and diversification are two different development strategies. Firms can be successful in either way. In order to reflect this issue, in this paper, the influence in international market of a company listed in the top 10 of any specialized fields is considered as the same with a company involved in all the fields of construction industry. This means that if there are nine fields in the construction industry and a company is only involved in one field, it is listed in the top ten of this field. The number of its involved fields will be counted as 9 and not 1.

In summary, the International Advanced Index of a certain country's international construction industry is the sum of DI, HI and WI, because the "advance" of a certain country's construction industry could be reflected from these three aspects. This research will calculate the International Advanced Index of Chinese and US construction industry between 2000 and 2009, and hence be used to explore and compare the trends of the Chinese and US construction industry's international performance.

4. Comparative research

Comparative research is the methodology that was used for the research reported in this paper. Comparative research is the act of comparing two or more things with a view to discovering something about one or all of the things being compared (Heidenheimer *et al*., 1983). Comparative research is a research methodology in the social sciences that aims to make comparisons across different sectors. A major problem in comparative research is that the data sets in different groups may not use the same categories, or define categories differently (for example by using different definitions of poverty).

There is not an agreed opinion on when the practice of comparative research began. Comparing things could be considered to be the essential to basic scientific and philosophic inquiry (Deutsch, 1987). Textbooks on this form of study were beginning to appear by the 1880s, but its rise to extreme popularity began after World War II (Clasen, 2004). This technique often utilizes multiple disciplines in one study. The multidisciplinary approach is good for the flexibility it offers (Jones, 1985). Quantitative analysis is much more frequently pursued than qualitative, and this is seen in the majority of comparative studies (Deacon, 1983 and Esping-Anderson, 1990).

Comparative research can take many forms. Two key factors are space and time. For the space perspective, cross-national comparisons are very common. There are numerous reasons that cross-national comparative research has become an important methodology for the social scientist. Globalization has been a major factor by increasing the desire and possibility for intellectual curiosity about other countries and cultures, and providing the background and environment. Information technology has enabled greater production of qualitative and quantitative data for comparison, and international communications technology has facilitated this information to be easily spread (Clasen, 2004). Recurrent interregional studies include comparing similar or different countries or sets of countries, comparing one's own country to others or to the whole world (Heidenheimer *et al*., 1983). For the time perspective, the historical comparative research approach involves comparing different time-frames. The two main choices within this model are comparing two stages in time (either snapshots or time-series), or comparing the same thing over time (Deacon, 1983).

For this paper, because the Chinese and U.S. construction industries will be analyzed, there is place difference. In addition, this paper will also compare the performance and position of the Chinese/US construction industry between the different time (2000 and 2009) in order to find the development of the Chinese/US construction industry. Therefore, this paper will adopt both cross-national and historical comparisons. The international performance of the Chinese and US construction industries between 2000 and 2009 based upon the International Advanced Index will be compared to identify the changes in both countries' construction industry and differences between countries.

5. Data collection

In this paper, the analysis is limited to the Chinese and United States multinational construction enterprises. The importance of multinational enterprises in leading and shaping the performance of the industry is paramount and it has been acknowledged by various researchers and social institutions in the world (United Nations, International Monetary Fund, etc.) because of their massive financial, technological, human, intellectual, and organizational resources (Kanter, 1995 and Korten, 1999). In the international construction sector, most of the direct participants are multinational enterprises. In this sense, the level of multinational enterprises' development could be considered as the indicator of the country's level of development. Therefore, in this paper, the multinational enterprises will be studied as cases.

The annual report on the top 225 international contractors provided by Engineering News-Record (ENR) will be adopted; however, some limitations should be discussed. Firstly, the quality of the data depends on the willingness of firms who wish to participate in the ENR's survey. Firm's level of participation can influence the data and ranking. For example, the lack of participation by British contractors-Trafalgar House PLG in 1996 and Kvaener Group and Bovis Construction Ltd in the ENR survey in 1999 resulted in a dramatic change in the data and ultimate rankings. In addition, the authenticity of data depends on the firms' honesty. Despite these limitations the data provided by the ENR is also the most comprehensive data set currently available.

For the International Advanced Index of the Chinese and United States construction industry in the international market, it is difficult to gather data for the Depth Index. Therefore, adopting the ENR's statistics, Depth Index is generated as the ratio of overall international revenue of all Chinese or US companies to total international revenue of all companies in the list. In addition, Height Index is measured as the number of a country's construction enterprises in the top 225 international constructors list and the "weight", which is the value of the average international revenue in the top 100 international constructors to the average international revenue in the rest 125 (Zhang & London, 2010). The "weight" is called Gap index (GI) which is the indicator of the gap between the top international constructors. The smaller value indicates the smaller gap between these top companies, and vice versa. The formula of HI is as follows:

$$\mathrm{HI} = \frac{\mathrm{No.\,of\ CCCEs\ in\ top\ the\ 100\ ICs\ list} \times \mathrm{GI} + \mathrm{No.\,of\ CCCEs\ in\ the\ rest\ 125}}{225} \quad (1)$$

$$\mathrm{GI} = \frac{\sum_{i=1}^{100} f(Ti)}{\sum_{i=101}^{225} f(Ti)} \times \frac{125}{100} \quad (2)$$

Though the previous International Advanced Index considers the differences between the top 100 and the rest of the 125 construction companies by using the Gap Index, the difference between each company should also be measured, not only in groups. Therefore Zhang and London (2011) developed a rank score to reflect this issue. According to the rank of these companies listed in the top 225 international constructors, the top company is given a score of 225; the second is 224 scores, and so on. The High Index of a certain country's construction industry is the average rank score to the total number of companies in the list, 225. The higher value of High Index shows the better performance of the country's construction industry in the global market. The High Index is calculated by the following formula:

$$\mathrm{HI} = \frac{\mathrm{Average\ Score\ of\ CCCEs\ in\ the\ top\ 225\ ICs\ list}}{225} \quad (3)$$

Furthermore, according to the classification of ERN, there are 10 specializations in the construction industry. However, the data of Industrial sector and Petroleum sector are categorised in the same group by ENR. Therefore, in this research, these two sectors are considered as one field in construction industry. In this sense, there are nine fields in total in the construction industry. ERN also provides the number of Chinese and United States construction enterprises listed in the top 10 of each specialized fields. The formula for generating WI is:

$$\mathrm{WI} = \frac{\sum_{i=1}^{N} f(W'i)}{N} \quad (4)$$

$$\mathrm{N} = \mathrm{No.\,of\ CCCEs\ in\ top\ 225\ IC\ list} \quad (5)$$

$$f(W'i) = \frac{W'i - M + 9M}{9} = \frac{W'i + 8M}{9} \quad (6)$$

$$W'i = \mathrm{No.\,of\ fields\ each\ CCCE\ involved} \quad (7)$$

$$\mathrm{M} = \sum \mathrm{NO.\,of\ CCCEs\ listed\ in\ top\ 10\ of\ each\ field} \quad (8)$$

6. Results and discussion

Although China is one of the most ancient civilizations in human history, it has recently in the last decade made dramatic moves towards modernization and marketisation. After the implementation of the "reform and opening-up policy" in the 1980's, China embarked on a road of revival. In 2007, Foreign Direct Investment (FDI) in China reached 83.52 billion U.S. dollars, ranking No. 6 in the world, accounting for 16.7% of the total of developing countries. China's level of FDI ranks first among developing countries for the last 17 years consecutively (National Bureau of Statistic of China, 2008). It has often been claimed by both the popular business media and academic experts alike that the 21st century will be the Chinese century (Dyer, 2009; Thayer, 2009; Chan, 2008; Smith, 2006 and Hines, 1997).

Regardless of the rhetoric it is important for us to understand these most recent changes on construction industry performance. The Chinese construction industry has undergone a dramatic change caused by internationalization in recent years, and as a result became integrated into the world economy to a greater extent. Chinese construction enterprises have accounted for 54 among the world's top225 international constructors in 2009 (Reina & Tulacz, 2010). The total international revenue has change from $5.4 billion in 2000 to $50.6 billion in 2009 (Reina & Tulacz, 2001 and 2010).

The International Advanced Index has risen from 0.939 to 1.0329(Table 1). The Depth Index has increased from 0.046 to 0.132, which means the Chinese construction companies have received a greater share in the international market, and the Width Index has also increased from 0.4412 to 0.467, indicating that Chinese construction companies have been involved in an increasing number of fields in the international construction market. The Height Index declined from 0.4518 to 0.4339, which means Chinese construction companies' ranks are very low, even though the number of Chinese construction companies listed in the top 225 is increasing.

In contrast, as a traditional developed country, United States plays an important role in the world. Many sectors of the United States lead the world economy. The total revenue from the international market of US construction companies has increased from $25 billion to $49.76 billion. Though there are only 20United States construction enterprises listed in the ERN top 225 international constructors in 2009, which declined from 73 in 2001, the International Advanced Index of US construction industry has dramatically increased from 1.0509 to 1.5221(Table 1). However, the Width Index has decreased from 0.215 to 0.135, which means the percentage of international revenue of US construction industry in the international market is reducing. This decline could be caused by the improvement and growth of developing countries' construction industry and their activities in the international market. The Width Index and Height Index were more than 50% growth from 2000 to 2009, which indicates that the US construction companies have involved and affected more fields of international construction market, and the top construction companies' 'quality' is increasing.

From Table 1, the International Advanced Index of both the Chinese and US construction industries have increased from 2000 to 2009. However, the growth rate of the Chinese construction industry is only about 10%. In contrast, the US construction industry has achieved 50% growth in 2009, compared with 2000, based on the International Advanced Index. The gap between the Chinese and US construction industries has increased, from 0.1119 in 2000 to 0.4892 in 2009. In addition, the quality of Chinese construction companies is decreasing. Also, the fields which Chinese construction industry companies are involved in are not significantly increasing. However, the US construction companies enter into more fields, and actually nearly all the fields. Therefore, it could be claimed that, China's construction industry has made some achievements from internationalization. However, compared with developed countries, the benefits derived from internationalization by the Chinese construction industry are much less. There appears to be a trend of a widening gap between developing and developed countries within the context of internationalization. This result is somewhat perplexing as one assumes that internationalisation provides benefits. It could not be simply said that internationalization is not advantageous for the Chinese construction industry. We can only speculate that perhaps the incorrect process of internationalization has been adopted by the Chinese construction industry. The internationalization strategy undertaken by this developing country requires modification or fine-tuning in order to narrow the gap of growth rate with developed countries.

Table 1: Comparison of Chinese and US construction industry

Index	*Chinese construction industry*		*US construction industry*	
	2000	*2009*	*2000*	*2009*
DI	*0.046*	*0.132*	*0.215*	*0.135*
HI	*0.4518*	*0.4339*	*0.3671*	*0.5093*
WI	*0.4412*	*0.467*	*0.4688*	*0.8778*
IAI	*0.939*	*1.0329*	*1.0509*	*1.5221*

7. Conclusion

With the development of internationalization and globalization, the Chinese construction industry has become involved in the international market more and more deeply. Some changes and developments have occurred in the Chinese construction industry, including 1) the Chinese construction market is extremely large and growth has been rapid; 2) the Chinese construction industry now provides a diverse range of jobs and offers many new opportunities; 3) the level of technology has continuously improved; 4) the classification of firms in the Chinese construction industry has changed from three categories (State Owned Enterprises, Urban and Rural Collectives and Rural Construction Teams) into five categories: State Owned Enterprises, Collective Owned Enterprises, Private Owned Enterprises, Enterprises Founded by Hong Kong, Macao and Taiwan, and Foreign Founded Enterprises; and 5) the organizational structure of the Chinese construction industry has changed after joining the WTO.

By conducting the comparative analysis between the Chinese construction industry and the US construction industry in 2000 and 2009 based on the International Advanced Index, we have found that both Chinese and US construction industries have made some improvements. However, the gap between the construction industry performance of these two countries is becoming larger, especially in the number of fields they are involved in and the ranking of the top companies. This situation should be of interest to policy makers as they seek to generate appropriate strategies for the Chinese construction industry's further development. It is speculated that the current development strategy could be reconsidered. In particular the process of internationalization could be more carefully reviewed to search for ways to narrow the gap with developed countries, for example, by involving more construction fields and improving the position of the Chinese construction companies in international competition. Internationalization is a popular strategy, however, based upon the findings of our research; it is argued that internationalization may not necessarily change the position of Chinese construction companies in the international market. It appears that Chinese construction companies may still be at a disadvantage when they compete with companies from developing countries. Therefore, specific ways on how to improve the competitiveness of Chinese construction industry is an area worthy of further research.

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Comparative Study of Japanese and Korean Construction Industries' Overseas Market Strategy

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Abstract

In recent years, there has been progressive opening of the construction market along with globalization. The need for market analysis and strategic initiatives associated with Japan's and Korea's intensifying competitiveness in the overseas construction market has received much attention not only at the level of construction companies but also at the national policy level. As part of the development process of Japan's and Korea's construction industry, expansion into overseas construction markets has been promoted on the basis of the industry's own experience. In order to clarify Japan's and Korea's strategies for expansion into overseas construction markets, this paper analyze consecutively the behaviour of construction companies and their strategies and the support policies of both countries. To do so, this paper examines the change in the expansion into the overseas construction market and the meaning of such expansion in the light of the current state of the construction industry of both countries. The analysis reveals that in Korea, the orders focus on plant construction, the improvement of the external environment of construction companies, and the globalization of the domestic construction industry, a strategy that enables the diversification of work classification and engineering fields. However, in Japan, the maintenance of the external and internal environment of construction companies to ensure stable orders in countries where Japanese companies are already established and the international expansion of Japan-style building construction systems are being carried out on the basis of their superior technology.

Keywords*:* Overseas market, Support system, Strategy, Globalization, Construction industry

1. Introduction

1.1 Background of research

In recent years, the construction market in Japan has been shrinking, and the competition for orders has intensified. Expansion into overseas construction markets has been considered a suitable countermeasure for meeting the current challenges; on the other hand, the debate over the cause of the failure of past overseas construction projects has received attention socially. Hence, Japan’s Minister of Land, Infrastructure and Transport (MLIT) has promoted overseas expansion through an organization called the Construction Industry Strategy Committee. However, focusing only on the improvement of the current construction-related legislation as the way to support expansion into the overseas construction market has its limitations. In order to advance into the overseas construction market, Japan should also identify the main causes of past failures as well as success factors, and comprehensively analyze the strengths and weaknesses in the strategies of competing countries. Against this background, the main goal of the present paper is to develop practical and concrete strategies to ensure Japan’s success in the overseas construction market. To achieve this objective, this paper performs comparative studies on construction-related legislation, overseas support systems, association-related activities, and the countermeasures of construction companies in Japan and Korea. The latter country is chosen in the analysis since it is Japan’s biggest competitor and has expanded aggressively into the construction markets in the Middle East and Southeast Asian countries.

1.2 Research method and purpose

On the basis of the research background, the research method and purpose are presented as follows: (1) Benchmarking studies on the strategies for the overseas construction market by using data and literature published in Korea. (2) Clarifying the support structures and the institutional differences for the overseas construction market by considering the information and legal systems of the related organizations and the differences between Japan and South Korea in terms of their history and motivation for entering the overseas construction market. (3) Clarifying the strategies and behaviour of construction companies that pursue expansion into the overseas construction market, on the basis of previous studies and surveys.

1.3 Research method and purpose

In Korea, studies on trends and prospects in the overseas construction market (Choi et al., 2003) and medium and long-term strategy (MLTM, 2007) were carried out first. In Japan, several studies have been carried out by The Japan Research Institute, Ltd. (JRI, 2004) and the MLIT (2006). However, it is difficult to understand the motivation and reasoning behind the strategies for entering the overseas construction market because these studies deal with the countries’ urgent problems in the face of the current status of competing countries. This paper considers the meaning of and the change in the expansion into the overseas construction market in the light of the current state of the construction industry in both countries. Furthermore, the behaviour of construction companies, their strategies, and the support policy of both countries are analysed consecutively.

2. Overview of the construction industry in both countries

2.1 Construction investment and economy

Both Japan's and Korea's construction industry played a role in rebuilding their countries after the Second World War, and have grown into a main industry whose impact is felt on other industries. Table 1 shows the comparison of the key indicators of the construction industry in both countries. The ratios of GDP and construction investment of both countries are about 1:5 and 1:3, respectively. While most of the key indicators of Japan are a little larger than those of Korea, its ratio of construction investment to GDP is smaller than that of Korea. This may be due to the reduced construction investment in Japan after the collapse of Japan's bubble economy, the small-business sector intensifying competition for orders in the domestic construction market, and the severe burden of high wages.

Table 1 Key indicators of construction industry in Japan and Korea (2010)

	Korea(MLTM, 2011)	*Japan(JFCC, 2011)*
GDP (Billion dollars)	*1,029.8*	*5,400.9*
Over last year (%)	*10.1*	*0.4*
Total population (Thousands)	*50,515*	*127,510*
GDP/Total population (Dollars)	*20,384*	*42,354*
Construction investment (Billion dollars)	*137.9*	*466.9*
Over last year (%)	*-1.4*	*-3.0*
Construction investment / GDP (%)	*13.4*	*8.6*
Land area (km^2)	*100,212*	*377,947*
Construction investment density (Thousand dollars/km^2)	*1,375.6*	*1,235.1*
Number of companies (Company)	*101,525*	*498,806*
Construction investment/Number of companies (Thousand dollars)	*1,357.8*	*935.9*
Number of employees (Persons)	*1,753,000*	*4,980,000*
(Construction industry/All industries)(%)	*7.4*	*8.0*
Construction investment / Number of employees (Thousand dollars)	*78.6*	*93.8*
Number of employees / Number of companies (Person/Company)	*17.27*	*9.98*

Note: average rate of 2010 (1 Dollar = 1138.9 Won = 88.09Yen)

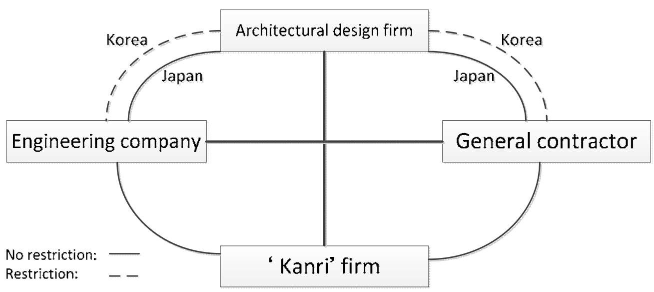
2.2 Construction-related legislation and construction organization systems

(1) System of construction-related legislations:

There are no differences in the kind and basic content of the construction-related legislations established by Japan in the late 1940s and Korea in the late 1960s. The following characteristics are included in each country's own construction-related legislations, which are established and changed based on their commercial practice, construction environment, and social system; i) Provision-centred construction-related legislations in Korea: Unlike the traditional building construction system, the construction-related legislations in Korea have been subdivided into detailed sections so as to promote the stability of the construction industry in the post-war reconstruction work. This fact can be seen from the following examples: the depth of detail about construction techniques in each item, the Overseas Construction Promotion Act (1975) for securing the quality and safety of construction works, and the Construction Technology Management Act for the promotion of the overseas construction industry. The construction-related legislations have become the standard of judgment in both private and public sector construction works. Those announced by the Korean government, but not the clauses based on social agreement, are the ones used in creating contracts and orders. Furthermore, in recent years, basic laws on construction have been enacted to adjust the role and regulations of the construction-related legislation; ii) Purpose-oriented construction-related legislations in Japan: The modernized building construction systems of Japan, which are based on the traditional production system, have been used as a minimum standard in the guidelines and provisions of the private sector. Although Japan's legislation is considered to be relatively flexible compared to that of Korea, the construction-related legislation and the building construction system, were recently made more rigid because of several construction-related accidents.

(2) Difference of construction organization system

Although the classification of the construction industry in Japan is the same as that in Korea, there are differences in terms of construction organizational relationship, especially in the restrictions placed on the construction companies. For instance, in Japan, there is no restriction on construction companies, including architectural design firms, but in Korea, architectural design firms are restricted with regard to the work they do in fields outside of their particular specialty by the Certified Architect Act.



※「'Kanri'firm」in Japan, Korea and China, plays a similar role for supervision or inspection in the USA , and it acts the clerk of works in the UK. 'Kanri' is referred in Chinese characters:「監理」in Japan, Korea and China, but strictly speaking those detailed work scopes are different from those in the USA and UK.

Figure 1: Restrictions on construction companies in Japan and Korea

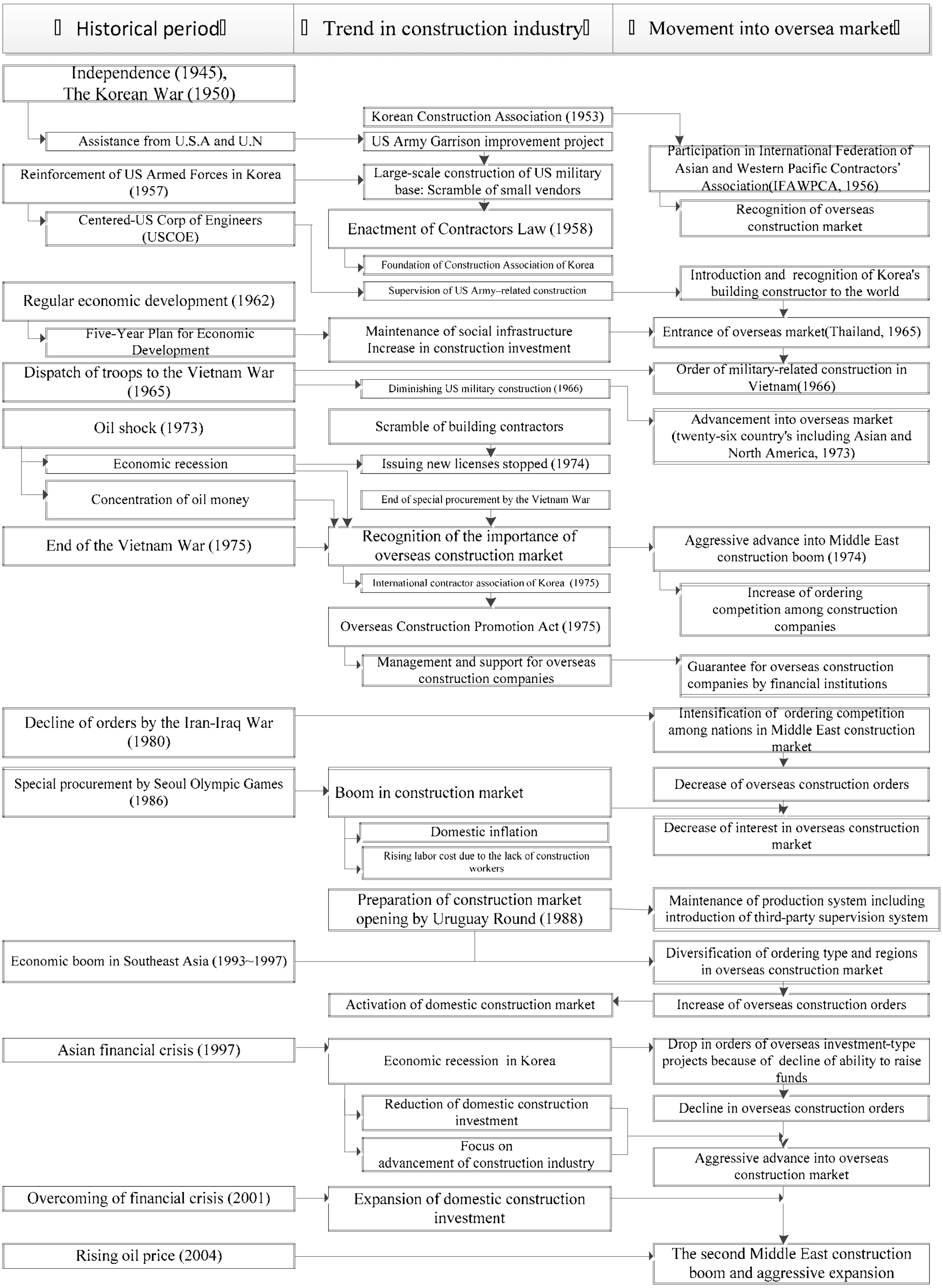


Figure 2: History of overseas construction market in Korea classified by historical period, trend of construction industry, and movement into overseas construction market (KIA, 2011 & Choi, 2006)

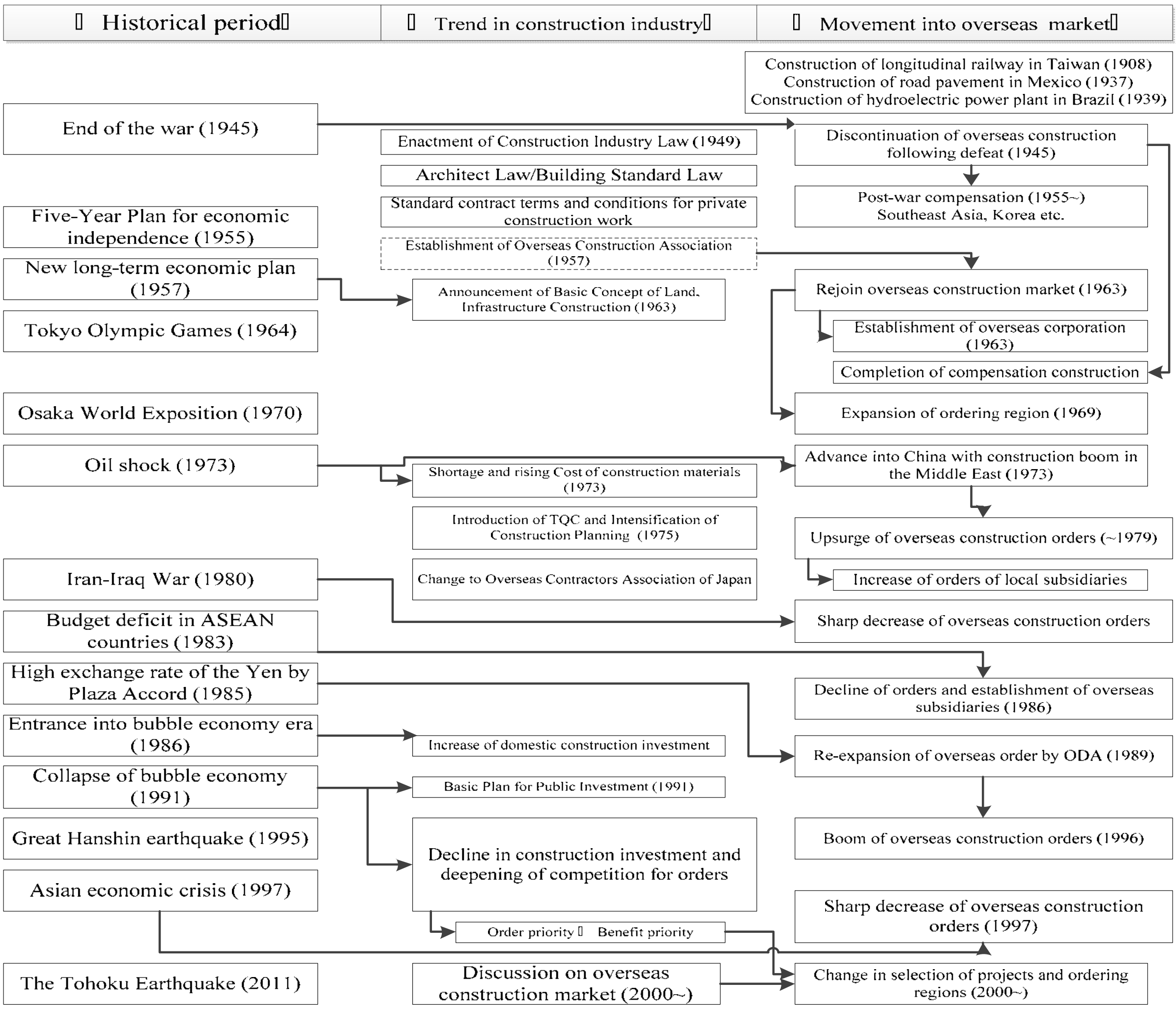


Figure 3: History of the overseas construction market in Japan classified by historical period, trend of construction industry, and movement into overseas construction market (MLIT, 2005)

3. State of affairs regarding expansion into overseas construction market

3.1 Change in the expansion into overseas construction market

(1) Expansion from domestic construction market into overseas construction market in Korea

Figure 2 presents the history of the overseas construction market classified by historical period, the trend of the construction industry, and the movement into the overseas construction market, respectively, in Korea. The history of the expansion into the overseas construction market in Korea began with the expansion into South Asia, following the experience with the construction of U.S. military bases after the Korean War. Subsequently, the Korean government took an interest in the overseas construction market with the orders for military-related facilities during the Vietnam War and with the increase of construction investment due to domestic infrastructure. Moreover, in the 1970s, such orders grew exponentially with the Middle East construction boom. However, orders in the Middle East did not last due to a decrease in order quantity with the outbreak of the Iran-Iraq War (1980s) and intensifying competition for orders. This decreased the interest in the overseas construction market. Subsequently, the construction industry in Korea engaged, in earnest, in overseas construction marketing while preparing for the opening of the domestic construction market and piggybacking on the second construction boom in the Middle East and the economic development in Southeast Asia.

(2) Separation of domestic and overseas construction market in Japan

Figure 3 presents the history of the overseas construction market classified by historical period, the trend of the construction industry, and the movement into the overseas construction market, in Japan. While Korea has advanced into the overseas construction market due to its small domestic construction market, Japan has focused on its huge domestic construction market while piggybacking on ODA (Official Development Assistance) and the construction boom in the Middle East. In recent years, in Japan, discussions on stabilizing orders in the overseas construction market have been ongoing because of intense competition for orders in the domestic construction market caused by the fall-off in construction investment after the collapse of Japan’s bubble economy.

3.2 State of affairs of overseas construction orders

(1) Analysis of contract amount by region

Figures 4 and 5 indicate the contract amount in Korea and Japan, respectively, by region. Although over 90 percent of the countries in which Korea’s construction works are in progress are in Asia and the Middle East, the number of countries where orders are being gained has also increased along with the overall increase in the number of orders since 2007. This has been a result of companies’ efforts to diversify the countries from which orders are sought, to prevent sole dependence on orders from the Middle East. On the other hand, Japan is focused on the Middle East, Asia, and North America, perhaps owing to its strictly screening projects for benefits since the mid-2000s.

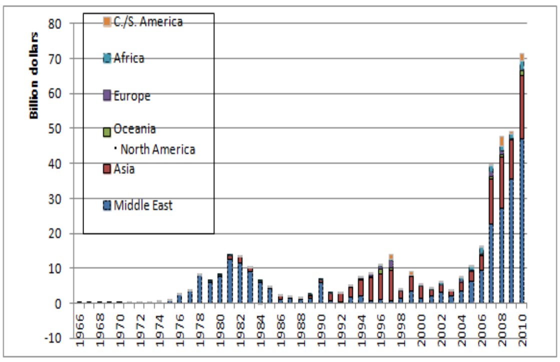


Figure 4: Contract amount by region in Korea (ICAK, 2011)

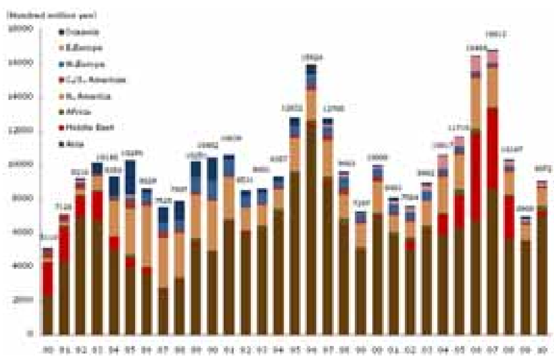


Figure 5: Contract amount by region in Japan(OCAJI, 2010)

(2) Analysis of order by work type

The orders by work type in Japan have been diversified into construction and civil engineering, including plant construction. However, Korea has focused on plant construction since the late 1990s. This focus may be due to the change from the skilled worker dispatch-centred overseas construction projects to the technician-centred projects, which make use of techniques related to heavy industry.

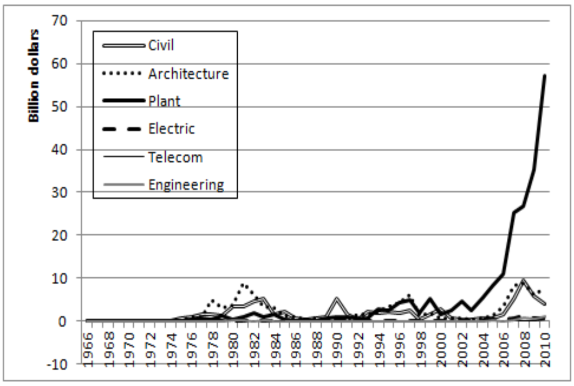


Figure 6: Orders by work type in Korea (ICAK, 2011)

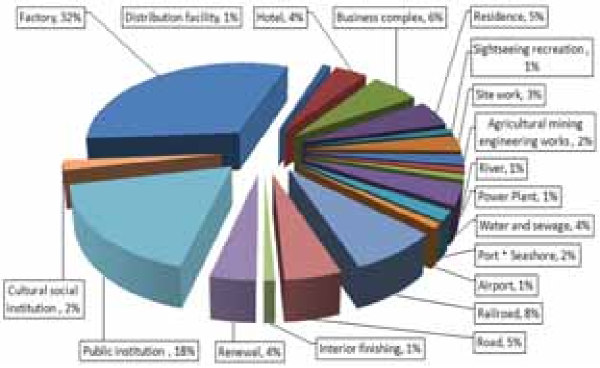


Figure 7: Orders by work type in Japan (OCAJI internal data, 2010)

4. Support structure for expansion into overseas construction markets

Since the 1970s, the Korean government has implemented policies to support domestic construction companies' expansion into the overseas construction market. It has encouraged the overseas expansion of the construction industry through the enactment of the Overseas Construction Promotion Act (1975) as a means of securing foreign currency. The following are examples of supportive policies by the Korean government: (i) providing information on overseas construction orders, (ii) education and training, (iii) reporting the state of construction and construction orders, and (iv)recommending collaboration between domestic companies. In addition, the International Contractors Association of Korea (ICAK), established on the basis of the Overseas Construction Promotion Act (1975), is responsible for substantial activity. As of February 2012, the Overseas Construction Association of Korea has a membership of 695 companies and has opened a database including information related to individual orders, materials, human resources, and risk to its member companies. The International Contractors Association of Korea not only provides such information but also carries out a broad range of other activities, such as international negotiations for orders in the private sector, education and training of human resources, assistance in covering the cost of overseas market research, and dispatching independent research groups. Moreover, it grants extra points, as support and incentive for overseas construction orders, to private construction companies that have a track record in filling overseas construction orders, during the PQ (Pre-qualification) process for domestic public projects.

Compared to Korea, where the central government provides support, Japan has few institutional supports for the expansion of construction companies into the overseas construction market. Japan's construction industry has advanced into the overseas market on the basis of the superior technology of private construction companies. Despite notable achievement in building a fiduciary relationship between customers and companies over long periods in some areas, the national support structure has in recent years come under discussion following defeats in the bidding process in the overseas market. Moreover, though the Overseas Contractors Association of Japan was founded in 1957 as a competent authority, it has not played a central role in Japan. Only 48 member companies registered in the Overseas Contractors Association of Japan have advanced into the overseas construction market and the exchange of information and education is carried out by the staffs of the member companies.

5. Expansion strategies for overseas construction markets and behaviour of construction companies

5.1 Expansion strategies for overseas construction markets as a nation policy

In Korea, the Construction Technology Development Action Plan (2005), the Comprehensive Countermeasures for Overseas Construction Support (2008), and the State of Overseas Construction and Activation Methods (2010) were published by the Ministry of Land, Transport and Maritime of Korea, and those documents' contents are under discussion and review in many symposiums. Those contents and strategies are summarized as follows.

i) Development of new markets and new products: The diversification of the overseas construction markets should be promoted by proposing development and investment-oriented businesses and package-deal type businesses in Central Asia and Africa, as well as increasing efforts to generate orders in the existing markets. For its implementation, however, construction companies should have architectural design and engineering capabilities, and EC (Engineering Contractor) or EPC (Engineering, Procurement, Construction) should be carried out, as illustrated in Figure 1.

ii) Intensification of support measures for construction orders: The implementation of new support measures should be simplified and unified by the establishment of overseas construction-related institutions of the government and the intensification of existing support systems for educating and maintaining human resources.

iii) Improvement of ratio of foreign exchange reserves: The benefits obtained from projects should be increased through registering domestic materials to foreign vendors; the profitability and the order information should be analysed and examined by ICAK and other experts before bidding commences.

In Japan, the report on the environmental arrangement of the overseas construction market (2002) and the report on the overseas development strategies of the domestic construction industry (2006) were published by MLIT. These reports were based on the necessity for expansion into the overseas construction market in response to the decreased domestic construction investment. In the private sector, national support systems are mainly discussed. Those contents and strategies are summarized as follows.

i) Intensification of risk measures: As a result of the Japanese-style building construction system, which is based on a fiduciary relationship between manufacturers on overseas construction projects, there needs to be a correspondence between the exchange rate risk and the country risk, in the light of the decreased benefit in recent years. For its implementation, the burden on the private sector should be reduced by improving the construction risk-sharing scheme and the trade insurance system.

ii) Selection and concentration: Competitiveness in the overseas market should be secured by focusing on orders or region-centred projects in which the superior technology and know-how of Japanese construction companies will be of practical advantage.

iii) Fostering human resources and knowledge succession: Knowledgeable people with experience in overseas construction should succeed in ensuring communication, thus, fostering human resources that would be helpful in the overseas construction projects.

5.2 Behaviour of construction companies

In order to clarify the behaviour of construction companies with regard to the expansion into the overseas construction market, the business activities and support items implemented and/or demanded by the construction companies in Japan and Korea that have advanced into overseas market are organized in order of priority on the basis of a survey and reference 2. The survey on the expansion strategy of the Japanese construction industry into the overseas construction market was conducted by the authors in Japan from December 2011 to January 2012. Table 2 shows the intensification of the bidding competition by the construction companies, which information is compiled on the basis of the results of our survey. The Korean government intensified their national support measures, recognizing that the systemic improvement of the financial sector was the most important task. In the case of other work types except plant construction, maintaining the external environment of construction companies is necessary because their technical competitiveness is weak. Japan, on the other hand, promotes stable settlement in the existing overseas market, rather than developing new markets, using ODA as a basic policy. For this reason, Japan tries to maintain the external environment of construction companies, and the internal environment of construction companies such as their core business based on superior technology.

Table 2 Response and request of companies to intensification of bidding competition

Korea(MLTM, 2007)	*Order of priority*	*Japan (Questionnaire results)※*
Expansion and improvement of public finance such as the EDCF(Economic Development Cooperation Fund)	*1*	*Expansion and active utilization of ODA(Official Development Assistance)*
Intensification of bidding competition of Export-Import bank	*2*	*Intensification of negotiation and collaboration between governments for risk-sharing*

Improvement of bidding competition of small business in engineering fields	*3*	*Fostering and securing of human resources*
Intensification of incentives for expansion of overseas construction	*4*	*Support for managing trade terms and spread of trade insurance*
Standardization and globalization of domestic construction industry	*5*	*Building of local network*
Intensification of support of government-funded institutions	*6*	*Careful selection of advanced countries, regions, and work types*
Support for expansion of market development funds	*7*	*Intensification of top sales by government*
Education and training of professionals	*8*	*Support for formulation of projects and consortiums*
Expansion of overseas construction information network	*9*	*Securement of communication ability*
Establishment of overseas construction bond investment	*10*	*Development of finance (Use of JBIC(Japan Bank for international Cooperation))*
Building of risk management system	*11*	*Maintenance of risk management for overseas market*
Support of overseas construction by mutual aid associations	*12*	*Intensification of information gathering and provision*
Intensification of diplomatic missions construction	*13*	*Support of small and medium businesses for overseas expansion*
Improvement of competitiveness in plant area	*14*	*Analysis of merits and demerits of competitors*
Intensification of safety management for overseas construction	*15*	*Core business considering advanced markets*

※ Questionnaire data performed by authors.

6. Summary

This paper analyses in sequence construction-related legislations and support structures for the expansion of the overseas construction market, the activities of associations related to overseas construction, and the response of construction companies. It clarified that the globalization of the domestic construction industry and the maintenance of the external environment of construction companies are continuing in Korea, on the basis of the plant-centred diversification of advanced countries, regions, and work types. However, this paper shows that in Japan, the expansion of this industry is based on the country’s superior technology, international deployment of Japanese-style building construction systems, and the internal and external environment of construction companies, which continue to be used to stabilize orders in the developed markets. Future research should discuss the mechanism of problems and/or organization in the implementation phase of overseas construction projects.

7. Acknowledgements

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Modelling Social Sustainability in Built Environment

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Abstract

With the emphasis of creation of sustainable built environment over last few decades, numerous environmental standards have been emerging into the construction industry at an exponential rate. While more and more stringent standards are in place in achieving sustainable outcomes across projects, genuine emphasis on the issue on social sustainability in the societal settings has not been found widespread. In the context of value creation in built projects, appropriate methods for evaluating social performance is an important topic for investigation. While cost-benefits analysis is one of the most widely adopted practices in justifying benefits over investments in projects, the subjectivity associated with quantification of benefits is highly debatable. This research aims at devising a rational approach for integrating societal stakes into the value creation process. A framework based on stakeholder management and social network analysis for evaluating social sustainability has been developed. Using a case study from Saudi Arabia, the stakeholders are firstly identified according to their roles and their mutual relationships are investigated in the project. The impact of stakeholders is then evaluated according to their roles and relationships with other stakeholders using social network analysis. The resulting outcome of the social network model is demonstrated in order to determine the social performance index and then compared for a precise understanding of social value creation of the project within the built environment.

Keywords: social network analysis, stakeholders, cost-benefit analysis

1. Introduction

In the context of climate change and low carbon emmisions, “Sustainability” has been emphasised in development of projects across the globe. While the sustainability in layman’s term refers to the numerous green guides acorss project developmment processes, a holistic approach to quantification of sustainable outcomes in projects still remains a topic for investigation. Given that the built environment demands 40-50% of global resources and generates a proportional amount of waste, the construction industry, which contributes 5-10% of national GDP globally, has a prominent role to play in managing, controlling and meeting the sustainable outcomes across the projects (Langston, 2001). The terms, Triple Bottom Line (TBL) generally suggests that sustainability can be achieved in the intersection of social, economic and environmental performance, where a decision will not result in economic benefit, but also affects environment and society in a positive way (Elkington, 1998). In the concept of TBL, the goal of a business entity is to coordinate stakeholders’ interests and balance between the economic performance and social/environmental performance, rather than maximize shareholder’s benefit. While the concept of TBL is reasonably applied in sustainable project development, a clear consensus on the measure of social dimensions leading to social sustainability is not quite prominent in the industry practice (Salzmann et al., 2005).

Evidently, social sustainability has been strognly linked with the so called corporate social responsibility (CSR) in the TBL analysis of projects (Timur and Getz, 2008, Maignan and Ferrell, 2004). While stakeholder analysis and social benefits have been increasingly considered in the evaluation of social sustainability or corporate social responsibility (CSR), documented evidence analysing the influence of perceived interests of extended stakeholders from the planning and development perspective is quite limited across the companies and projects (Clarkson, 1995). Front-end evaluation of social performance in relation to stakeholder’s interests and influence is the key for achieving social sustainbility in projects. The focus of this research is thus on the quantification of the social benefit of investment at the outset of project creation, which comprises an important pillar of sustainability measure of project factility in the social or community context. In this research, the social benefit of investment in referred as social performance and social performance index (SPI) is a quantified measure of the social performance. A framework has been developed integrating stakeholders’ relative positions and thier underlying stakes to quantify the social benefits of investment in a given project . Based on stakholder therory and the social network Analysis (SNA) methdology, the framework provides a powerful platform for integrating community views associated with the project development environment and motivating industry professionals for underpinning sustainabile outcomes in the project.

2. Theoretical underpinnings and rationalisation

As asserted by the Brundtland (1985), the basis for sustainable development of a project, a company, or a community may not be always the economic returns, but the overall satisfaction of other human needs such and community benefits are the imporant concerns (Brundtland, 1985). It is increasingly recognized that social and environmental concerns cannot be regarded simply as “overheads”, but should be considered as primary objectives in parallel with the economic gains to a project (Allenby and Richards, 1999). The TBL, namely economic return, environmental concerns and social benefits, has to be integrated at strategic stage of a project, and should be rooted into economic and social activities in the project at all relevant scales (Allenby and Richards, 1999). In the wake of sustainable project development, social sustainability is an important component. The dimension of social sustainability within sustainable development framework emphasises the long-term social benefits flowing to the stakeholders as well as community at large. In order to achieve the long-term social benefits, social performance must be ensured during the project development stage.

According to Littig and Griessler (2005), social sustainability is defined as the relationship between nature and human society. The human society is usually mediated by the human activities that satisfy the extended human needs such as social justice, human dignity and participation of relevant stakeholders (Littig and Griessler, 2005). Thus, whether it's a project or a society, the sustainable development requires imperative to focus on social management of economic activities to ensure the equal distributions of resources and long term provision of social reproduction (Littig and Griessler, 2005).

In the context of a private project or company, social sustainability generally refers to corporate social responsibility (CSR), which is the ethics and social responsibilities along with the marketing benefits among the stakeholders resulted from corporate activities with a social dimension (Maignan et al., 1999). Maignan and Ferrell (2004) defined four primary viewpoints of corporate social sustainability, including stakeholder obligations, society obligations, ethical commitment and managerial perspective (Maignan and Ferrell, 2004). With the acknowledgment of social responsibility being essential to sustainable development (Maignan and Ferrell, 2004), social cost benefit analysis (SCBA) has been mandatory in many countries to evaluate social cost and impact of a business decision in major infrastructure projects (Coady, 2000). Notwithstanding the prevalence of SCBA application, it is criticized for practicality of quantifying social impact in the project (Babu, 2009). A number of non-market valuation approaches have been developed to quantify social benefit, including contingent valuation, travel cost, hedonic pricing and benefit transfer, however, the precision of the valuation is unclear (Boyer and Polasky, 2004). However, a clear consensus on any particular approach or methodology for quantifyting the social impact of project is not available across the current industry practice.

In recent years, Social Network Analysis (SNA) is becoming increasingly popular as a general methodology for understanding complex patterns of interaction (Carrington, 2005). The network perspective examines actors that are connected directly or indirectly by one or more different relationships (Haythornthwaite, 1996). Any theoretically meaningful unit of analysis may be treated as actors: individuals, groups, organizations, communities, states, or countries. Regardless of unit level, social network analysis describes structure and patterns of relationships, and seeks to understand both their causes and consequences (Haythornthwaite, 1996).

This research primarily concerns on the issues of social performance assessments with respect to extended stakeholders' contributions to the social sustainability of projects. Central to the evaluation framework is the strategy that companies can adopt to best achieve social objectives in projects by integrating the stakes of extended stakeholders. The Social Network Analysis (SNA) framework puts forward in this research demonstrates the importance of stakeholders' roles and responsibilities in relation to their relative stakes in evaluating social performance of infrastructure projects.

3. Social performance evaluation

In the analysis of triple bottom lines, social dimension is one of the three pillars for sustainability. Becker (1999) states that sustainable development should be characterised as articulating political and economic differences and introducing social justice in addition to environmental issues and financial concerns (Becker et al., 1999). Hodge (1999) also suggested that social sustainability should be equally important as ecological sustainability within the concept of sustainable development (Hodge, 1999). As the community increasingly aware of environmental and social impact of projects, social sustainability or corporate social responsibility (CSR) has been more and more emphasized (Littig and Griessler, 2005, Maignan et al., 1999). Many social impact assessment guideline and frameworks have been developed, including Interorganizational Committee on Guidelines and Principles for SIA, South Sydney Council SIA checklist, Vanclay's classifications of social impacts and Dow Jones sustainability index (Littig and Griessler, 2005).

Yet being recognized as one of the three dimensions of sustainability, the scope of social performance and understanding of social impacts remain obscure (Littig and Griessler, 2005). Biart (2002) suggests a narrow definition of social performance as the minimal social requirement (or critical social capital) and the challenges to the very functioning of society for long term development, as long term development calls for only limited social requirement (Biart, 2002). On the other hand, Brandl (2002) defines social sustainability as the relationship between social and ecological systems, which aims to stabilize the whole system and uphold the functionality of linked sub-systems (Brandl, 2002).

While social sustainability is clearly linked to the range of social needs and necessitates within the communities, the ideas of what really constitutes a decent life is highly subjective and depends on perceptions of various social groups. If personal needs such as food, housing, health care, freedom and liberty etc. are combined with institutional needs such as education, recreation/leisure, social relationships etc, a much broader of action and opportunity is required in the social value creation process. The major driving force behind society and socialisation in broadest sense is the creation of opportunities to meeting one's need and for that purpose, Malinowski (1988) suggests that categorisation of societal needs across meaningful functional systems is essential for shaping and controlling the relationships within the societal structure. for (Malinowski, 1988). In the society, there are three independent functional systems involved in social sustainability, with distinct aims and requirements for social sustainability (Parsons, 1966). The three systems are: *Economic system*, *Political system* and *Cultural system.* Economic system consists of the monetary economic activities in the project, including all services, infrastructures and stakeholders with regard to material reproduction. Political system consists of political attitudes, orientations, decisions and activities implemented by different institutes. The most important stakeholder with regard to political system is the government, as the project will be largely affected by the government's political orientations. Cultural system includes all culture related practices and patterns of the society, and the convenience and wellbeing that stakeholders obtain from the project.

Within a project, social performance requires the project to produce immediate benefits for stakeholders rather than simply the creation of shareholders alone (Malinowski, 1988). Stakeholders are the integral part of a project, including all the people who are capable to exert impact on the project, or will be influenced by the project. Thus stakeholder analysis and evaluation of their social performance allow identifying the degree of stakes among the stakeholders, prioritizing stakeholders in terms of their involvement in decision making and their interests in the project (Clarkson, 1995, Littig and Griessler, 2005, Maignan and Ferrell, 2004).

4. Social Network Analysis and stakeholders management

As mentioned earlier, in order to assess social performance of a project, it is essential to cover all the stakeholders' interests in the analysis. However, participation of all stakeholders in the assessment process is a challenging task. Some stakeholders may be difficult to identify, as they are marginalized from management decisions (Daniels and Walker 2001); pre-existing conflicts between stakeholders may lead to unwillingness to participate in assessment process (Stringer et al 2006); and some biased stakeholders from small groups may be not representative (Grimble and Wellard 1997).

In the investigation of the social relationships and analysis of social structures, SNA is a broadly used methodology in a number of academic fields (Carrington, 2005, Yang et al., 2010). SNA methodology allows modelling the social structure as a number of actors tied to one other through social relations. Therefore, by investigating the overall pattern of the network, flow of information through the network can be examined and the position of an actor in the network can be identified.

A social network is a structure composed of any bounded set of connected social units. Two fundamental components are defined in social network: sets of actors (nodes) and sets of ties depicting the interconnections (Doloi, 2011). From interviewing stakeholders in a project, the social network can be established with investigating the ties and the strength of the ties between actors. As defined by Granovetter (1973), "the strength of a tie is a combination of the amount of time, the emotional intensity, and intimacy, and the reciprocal services which characterize the tie." (Prell et al., 2009, Granovetter, 1973). Strong ties between actors indicate that they have more influence on one another, shares similar views, communicate more effectively and be more likely to trust each other (Prell et al., 2009).

With the information of how actors interconnect with each other, identifying the most influential stakeholders is essential for the stakeholder analysis. Centrality in the network identifies prominent actors who have high involvement in many relations, namely highly influential stakeholders in the network (Wasserman and Faust, 1994). The degree centrality is calculated by the sum of direct ties to other actors. Strong and extensive ties to other nodes indicate that the stakeholder is more likely to influence others, thus more important (central) in the network (Doloi, 2011).

Degree centrality is expressed in Equation 1 as below:

$$C_D(N_i) = \sum_{j=1}^{g} X_{ij} \Big/ (g-1) \quad where \;\; i \neq j \qquad \textbf{\textit{... Equation 1}}$$

Where $C_D(N_i)$ denotes the degree centrality for node i; $\sum_{j=1}^{g} x_{ij}$ sums up the intensity of direct ties that node i has to the $g-1$ but excluding j nodes (exclude node i itself).

Analysis of the interconnection between stakeholders implies the importance of stakeholders from degree centrality, whereas the satisfaction level of individual stakeholders can be derived from interviews or surveys. Thus social performance of the project can be identified from the satisfaction level of individual stakeholders and their influence in the network. Social Performance Index (SPI) is defined as the weighted sum of social value from individual stakeholders, according to their influence, i.e. degree centrality. In other words, the Social Performance Index (SPI) as a measure of social performance of the project is defined as the sum of social value from individual stakeholders multiplied by the influence of the stakeholder, i.e. degree centrality and the mathematical expression is shown in Equation 2.

$$SPI = \sum_{i=1} C_D(N_i) * S_i \Big/ \sum_{i=1} C_D(N_i) \qquad \textbf{\textit{......Equation 2}}$$

Where SPI is the social performance index, $C_D(N_i)$ is the degree centrality of node i, and S_i is the social value with regard to stakeholder i.

5. Application of SNA for Determining the Social Value – A Case Study

5.1 Case project brief

The Riyadh municipality in the kingdom of Saudi Arabia is currently developing a project called Economic Initiatives Project (EIP). The aim of the project is to provide a hub for any economic activities that related to societal welfare. A variety of economic activates and events are planned to run in the project such as farmer market, productive families market and flower market. Each day of the week is dedicated to selected activities, so each market will run on weekly basis. In addition, the building has been designed to provide a leisure space for the neighbourhood during the evening time. Facilities such as pedestrian walkways, social interactions joints and kids play grounds will be incorporated in the project design as well.

As this project will potentially bring a huge social impact to the society, it was selected to demonstrate the model implementation. Thus the key focus of the case study is to evaluate the social performance of the project. As the project is planned to be developed in phases, the farmer market being the first phase of project is currently under development. Based on a pilot study conducted on the farmer market development, the implementation of the assessment model is discussed in the following sections.

5.2 Identifying the stakeholders

Based on the interviews with the project authority and the project team, extended stakeholders associated with the project have been identified. A carefully designed questionnaire survey was hand-distributed among the users in the project site requesting to identify their roles and interest in the project. A total of eighteenth stakeholders identified in the project with their roles are listed in Table 1 and 2 below. The fourth column in Table 1 shows the roles of a particular stakeholder in the project.

After the identification of the stakeholders in the project, their interests in the project were identified through a separate questionnaire survey. Using a seven point likert scale, stakeholders were asked to assign the importance level of different social interests that the project may deliver in their perspective. It is worthwhile to note that the perceptions of the stakeholders on the importance level of different social values are considered to be their stakes in the project. This assumption is constant with social sustainability principles such as meeting stakeholders' expectations, enabling stakeholders' participations and enhancing society vibrant (Littig and Griessler, 2005). The resulting data were then analysed in *NetMiner* software package for generating appropriate network map and the relevant outputs. Figure 1 shows the map of the stakeholders influence network. The concept of degree centrality is used to quantify the stakeholder's influence. As stated earlier, degree of centrality indicates the prominence of the actors in the network. The higher the degree of centrality is, the more important the stakeholder is in the network.

Table 1. Stakeholders identified in EIP Building project

ID	*Name*	*Department*	*Roles in the project (from Table 2)*
1	*Participant 1*	*Riyadh municipality*	*1,3*
2	*Participant 2*	*The ministry of social affairs*	*2,3*
3	*Participant 3*	*The ministry of agriculture*	*2,3*
4	*Participant 4*	*Farmers*	*4*
5	*Participant 5*	*Customers*	*4,5*
6	*Participant 6*	*Commercial partners*	*4*
7	*Participant 7*	*Deliverers*	*4,5*
8	*Participant 8*	*Visitors*	*4,5*
9	*Participant 9*	*Designer*	*6*

10	*Participant 10*	*Construction contractors*	*6*
11	*Participant 11*	*Subcontractors*	*6*
12	*Participant 12*	*Maintenance contractor*	*6*
13	*Participant 13*	*Building supervisor*	*1*
14	*Participant 14*	*Facility Manager*	*1*
15	*Participant 15*	*Residential neighbour*	*4,5*
16	*Participant 16*	*Commercial neighbour*	*4,5*
17	*Participant 17*	*Paths and roads users*	*4,5*
18	*Participant 18*	*Evening time end user*	*4,5*

Table 2. Roles of stakeholders in EIP Building project

ID	Roles in the project
1	*Project owner*
2	*Strategic partner*
3	*Government inspector*
4	*End user*
5	*Neighbour*
6	*Supply chain member*

After identification of the stakeholder influence network, the social value of the project is assessed by individual stakeholders through a standardized questionnaire. The criteria to assess the social value are shown in Table 4. Stakeholders were requested to assess the performance of the project in terms of the criteria, as well as their interests in the project with a value from 0 to 5.

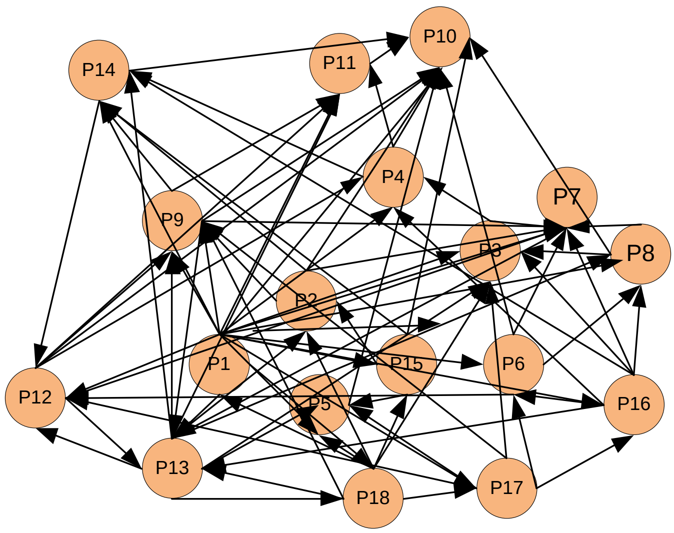

Figure 1: Illustrative SNA model on the case study

Table 3. Degree centrality and social value from individual stakeholders in EIP Building project

ID	*Stakeholders*	*Roles/Associations*	*Degree Centrality*	*Social value*
P1	*Participant 1*	*Riyadh municipality*	*3.9045*	*4.8*
P2	*Participant 2*	*The ministry of social affairs*	*3.8045*	*4.9*
P3	*Participant 4*	*Farmers*	*3.0902*	*4.4*
P4	*Participant 3*	*The ministry of agriculture*	*2. 9461*	*4.5*
P5	*Participant 6*	*Commercial partners*	*2. 8921*	*4.1*
P6	*Participant 5*	*Customers*	*2.8002*	*4.2*
P7	*Participant 7*	*Deliverers*	*2.7892*	*3.5*
P8	*Participant 8*	*Visitors*	*2.6734*	*2.7*
P9	*Participant 9*	*Designer*	*2.3943*	*2.9*
P10	*Participant 13*	*Building supervisor*	*2.0182*	*3.1*
P11	*Participant 12*	*Maintenance contractor*	*1.904*	*2.8*
P12	*Participant 11*	*Subcontractors*	*1.389*	*2.9*
P13	*Participant 10*	*Construction contractors*	*1.273*	*3.1*
P14	*Participant 14*	*Facility Manager*	*1.252*	*3.8*
P15	*Participant 16*	*Commercial neighbour*	*1.134*	*3.7*
P16	*Participant 15*	*Residential neighbour*	*1.034*	*4.1*
P17	*Participant 17*	*Paths and roads users*	*1.000*	*3.2*
P18	*Participant 18*	*Evening time end user*	*1.000*	*3.8*

The social value from individual stakeholder's perspective is derived from the assessment of their satisfaction level and their interests in the project. The interest of the stakeholders is converted into the weight for the criteria, whereas the individual evaluation of social performance is the weighted average of the satisfaction level. Social Value is thus can be expressed as:

$$SocialValue = \sum L_i I_i \Big/ \sum L_i)$$

……Equation 3

Where L_i is the satisfaction level in terms of the criterion i, and I_i is the stakeholder's interest of criterion i. The social value of the project for individual stakeholders is shown in fifth column of Table 3. Using the Equation 3, the overall social value of the project can be derived according to the individual social value and the respective stakeholder's influence in the network.

Table 4. Criteria of assessing social values in the case project

Social values	*Description*
Capital performance	*Ensure the economic sustainability of the project to satisfy relevant stakeholders. Improving financial performance while reducing threats in long term socio-ecological systems*
Internal human resources	*Social responsibility towards the workforce in the project, including employment stability, OH&S for the employees, training and career development, and the assets and infrastructures to maintain a productive life.*
Service provision	*The service and infrastructure provided by the project to meet the needs and maintain a satisfaction level for the users*
Community development	*The social and institutional relationships towards community. This include cultural heritage preservation, social cohesion, protection of human rights, etc.*
Regulation compliance	*The level of conformity of the project with current regulation, including certification, public safety and fair work requirement*
Intra and Intergenerational equity	*Ensure the sufficiency and effective choices pursued in a way to reduce the gap between different groups of people and preserve opportunity and capabilities for the future generation.*
Information provision	*The quantity and quality of information shared with stakeholders*
Stakeholder influence	*The degree to which the project actually incorporate stakeholder's opinion into operational decision making.*
Economic welfare	*The external economic impact of the project, including contribution to GDP, taxes, foreign trading opportunities etc.*
Socio-environmental performance	*The contribution of the project to the improve of environment, including reducing green house gas emissions, reducing non-renewable energy use, protection of endangered species, etc.*

Applying the SPI formula in Equation 2, the SPI for the case project was calculated as 3.95. As seen in Table 3, the social values for ministry of social affairs, Riyadh municipality and ministry of agriculture in the case project were rated above 4.5 ($S \geq 4.5$). However, a few key stakeholders in the project such as farmers, customers and the commercial partners rated the project with relatively low social value. This is perhaps due to lack of proactive engagement and integration of the perspectives of these stakeholders in the decision making process of the project. The overall Social Performance Index (SPI) of 3.95 out of maximum possible value of 5.0 for the project indicates that the stakeholders are generally satisfied (approx. 79%) with the project. However the social value (or social impact) can be further improved by increasing the satisfaction level of most influential stakeholders in the project.

6. Discussion and Conclusion

This research introduces an integrated framework for evaluating social performance in the context of achieving social sustainability in infrastructure projects. The social performance is assessed based on social responsibility study and stakeholder management within the project development process.

Social sustainability is defined as balancing the relationship between social and ecological systems, and stabilizing the whole system by satisfying the demand of stakeholders in the project. The key contribution of this research includes 1) identifying the social needs and opportunities of the stakeholders in the context of social performance analysis 2) developing criteria for social value evaluation with regards to social sustainability performance 3) integrating the influence of individual stakeholders in social network and 4) generating social performance index in the project by synthesizing the needs of different stakeholders in the social network. A case study was used to demonstrate the applicability of the framework.

As the social performance is primarily focused on the attitude of the society towards the project, social network analysis is a powerful tool to analyze the influence of stakeholders and the impact of the project on the society. The application of social network analysis requires comprehensive understanding of the actors (stakeholder groups), their roles and relationships to other stakeholders associated with the project which is much more time consuming, complex and costly than traditional stakeholder analysis. Yet, SNA analysis provides meaningful insights in terms of stakeholders influence in project development contexts Social network analysis is applicable for social performance evaluation with complex multiple stakeholders, as it brings precision and deeper understanding in social relations. However, success of application of social network analysis highly reliant on the extensive collection of stakeholder's perceptions along with the precise identification of their roles, responsibilities and relative relationships among other groups in relation to the project.

In the absence of adequate documented evidence of such data, the SNA methodology may yield suboptimal degree centrality in the network which may potentially result a compromise in ascertaining the social performance of the project. Addressing the limitations of data collection process for successful application of the research in practice, it should however be noted that while the accuracy of data is the key for achieving objective outcomes in the social network analysis, integration with other traditional stakeholder management approach may simplify the data collection process. Introduction of project information in advance should improve participation rate and accuracy in response among the key stakeholders. While the current research conceptualises the social performance of projects in terms of a single social sustainability indicator, such analysis needs to be further extended across numerous decision points in the project development context. Participation of the specific stakeholder groups over relevant project development lifecycle with suboptimal integration of perceived social interest will make a significant contribution in achieving overall social performance in projects. However, the process would be quite complex due to involvement of multitude of stakeholders and varied interests over time and the further research is currently in progress for developing a meaningful assessment framework in the near future.

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A Comparison of Construction Cost and Technology Choice

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Abstract

Building economists have produced construction cost indices to allow for a comparison of building construction costs for a wide range of locations. These are updated regularly to enable building owners, contractors and investors to estimate the cost of an equivalent building on a per square metre basis. This method of computing construction costs, either in local currency, or adjusted using a purchasing power parity approach provides a reasonably accurate description of the cost relativities between countries. This focus on per square metre building costs disregards the differences in construction methods or technologies employed to construct buildings. Thus, they do not provide a complete insight into the reasons for the differences in construction costs observed across countries and localities. The aim of an ongoing research project is therefore to develop a construction cost index to compare the various methods of concrete construction that are available to produce the same build-up floor area. Differences in local practices, availability of local resources (materials, labour and capital), domestic building materials industries, and local regulations all combine to influence the construction cost of a building. An illustrative example of this framework is reflected in labour and plant constants for three concrete structural systems in Australia, UK, Malaysia and the US. The findings indicate that it is now possible to utilise simple ratios of material costs to labour rates to justify the choice of concrete construction technologies. These derived cost indices should be able to provide a rational method for selecting appropriate building technologies to suit the circumstances of the construction sector in different economies. This is important as countries continue to seek new ways of making construction products affordable as well as to stimulate the development of domestic construction industry.

Keywords: construction cost, construction technology, building economics

1. Introduction

Construction technology involves the choice of materials and the ‘means and techniques’ used in construction. Total building cost will be significantly influenced by the choice of technology and vice versa. For example, local and abundant construction materials can reduce transportation costs and limits price inflation as compared to foreign sourced materials. Also, when a technology is easily adopted by the building industry locally involvement of expensive external skilled manpower or contractors is eliminated. Similarly, local technologies and materials that are durable and inexpensive to maintain reduce the maintenance and life cycle cost of buildings. However, it is also possible that investments in new technologies may reduce the costs of construction in the long run when the technology becomes widely accepted locally. For example, though unknown for many years prefabricated building has become the least expensive and widely used technique in the public housing sector of many developing countries while in other countries in-situ construction remains the cheapest and most widely used (Warszawski, 1999). Policy makers need to continue to evaluate contextual conditions and formulate policies to advance the local industry in the most appropriate directions with regards to construction technologies. A careful choice of technology will have both economical and social impacts. Thus construction technology used must be constantly reviewed and, when necessary, redirected by appropriate policies to encourage more suitable options. Generally, the choice of construction technology may be influenced by many factors but total cost is the most rational criteria for evaluating alternatives. Other factors include design, availability of construction materials, exposure to hazards and risks, speed, climate, indoor comfort and energy efficiency, social cultural acceptance and appropriateness, environmental impact (demolition, recycling etc), availability of local skills and opportunities for participation of livelihoods. It may be argued that these other factors will ultimately translate into cost in one form or the other.

Building economists have produced construction cost indices to allow for a comparison of building construction costs for a wide range of locations, usually at major urban areas in developed and developing countries. These indices are updated regularly to enable building owners, contractors and investors to estimate the cost of an equivalent building on a per square meter basis. This method of computing construction costs, either in local currency (Davis Langdon, 2010), or adjusted using a purchasing power parity approach provides a reasonably accurate description of the cost relativities between countries (McCarthy, 2011). Existing indices often do not link cost with other important local conditions such as dominant technology used locally. In effect, the focus on per square meter building costs ignores the different construction methods or technologies employed to construct buildings. Thus, the use of these indices does not provide a complete insight into the reasons for the differences in construction costs observed across countries and localities. Cost advisors are not able to produce estimates that account for differences in construction practices especially construction technology which can vary significantly between countries. Also, existing international cost indices account for location conditions in a broad manner. At the project level, estimates produced using such an approach can lead to inaccurate estimates and the potential for cost overruns when projects are completed (Stapel, 2002). At the industry level, this estimating approach does not allow for economic evaluation of alternative construction techniques and may limit industry development with regards to construction technologies. While many previous studies (Davis Langdon 2010, Stapel 2002, Walsh and Sawhney 2004) have made cost comparisons between countries, relatively little or no study has linked total cost comparison to choice of construction technology and industry specific conditions. When locations indices are constructed and used to estimate the total cost of projects, it may be argued that the choice of technology is indirectly accounted for. However, the problem is: existing location indices are often constructed and are specified without any indication of what construction technology is referred to for each location represented by the indices.

Stakeholders in multinational projects (e.g., contractors, investors, international organizations, financiers, designers) need to understand the total cost of projects at the feasibility stage and prior to bidding and construction. They require sufficient information that can help them choose different construction technologies when planning projects in different environments. Knowledge of differences in costs between locations accounted for by differences in technology can help stakeholders choose the right technologies/techniques that give highest benefit in terms of value derived from projects. On top of that, the choice and investment in appropriate technology can facilitate and advance the development of the local industry.

The aim of this project is therefore to develop a series of construction cost indices which are linked to the various methods of construction that are available to produce that same square meter of building space. The differences in local practices, availability of local resources (raw materials, land, labour, capital and technology), domestic building materials industries, and local regulations all combine to influence the construction cost of a building. These indices will be derived from a compilation of the costs of building material, construction costs for various building elements, labour costs, capital costs together with the choice of construction method and technology employed. The findings will inform on many current research and policy initiatives: to manage the exploitation of indigenous resources, to develop domestic building materials industries, to improve construction methods, modernise and upgrade the construction sector in different countries. It will make it possible for countries to learn from each other in terms of choice of construction technology and how they impact economics of building, local economy and the growth of the local industry. The findings should also provide a rational method for selecting an appropriate building technology to suit the condition of the construction industry in different countries. This is important as countries continue to seek for ways of making construction products affordable as well as seek to encourage the development of domestic construction industry.

2. Background and Literature Review

Sultan and Kajewski (2006) indicated that in some developing countries, the construction industry is very dependent on the importation of construction components and materials combined with issues of high unemployment leading to high construction costs from imported materials, inflation and an unstable economy. Thus policies put forward by various countries to improve the economic performance of their respective construction industries need to be informed by a precise economic model that illustrates the link between the cost of inputs to the construction industry to the price of its outputs and its follow-on benefits to the national economy.

Recent work by construction economists (Stapel 2002, Walsh and Sawhney 2004, Best et.al 2010, McCarthy 2011) are focused mainly on gathering data on construction costs in major cities around the globe and conducting research to explain observed differences in these indices based on the type of building; whether the building is to be used as a hotel, premium office tower, or an industrial or manufacturing facility. The demand for these indices are driven mainly by investors from developed countries looking to invest in major growth areas, or by manufacturers seeking to relocate their operations to less expensive locations. On the other hand, local construction activities are organised by managers sourcing building materials locally, employing local or migrant labour, and selecting a method of construction that reflects the ability of the local industry aim to achieve a lowest cost solution.

This project therefore seeks to bring these two areas of research – construction cost economics and construction technology, to mutually inform on the technology choices available to the designers and builders, based on a succinct understanding of the fundamental cost factors in each location. If industrialists spend a hundred dollars to manufacture a product within its borders, the capital that is used to pay for materials, labour and other costs moves through the economy as each recipient spends it thereby generating further economic activities. Due to this multiplier effect, a hundred dollars worth of primary production can add several hundred dollars to the Gross National Product of that country. This is the reason an industrialised product-exporting/commodity-importing country is wealthy and an undeveloped product-importing/commodity-exporting country is poor. Although this economic theory is well known, it has not been considered seriously in many economic development models for the construction industry. Many developing countries seek to import expensive construction technologies or use high-tech products in their local construction sectors to improve productivity or quality of their products. Ganesan (2000) suggested that construction methods that provide greater employment be adopted in Sri Lanka to cater for the under-employment of the labour force.

Moavenzadeh (1978) found that designs by expatriate professionals are often poorly suited to locally available labour, materials, equipment and construction methods. Developing nations thus tend to rely rather heavily on aid from developed countries in the professional sector of the industry. In the developed countries, increase in the cost of labour relative to other inputs have led contractors to search for labour substitutes, perhaps through the use of more productive equipment or a more capital-intensive method of construction which reduces on-site labour requirements. It is very likely that the techniques currently being developed in the industrialised countries may not be especially suitable for use in developing countries due to their incompatibility with local conditions. Some older techniques relying less on capital-intensive methods and more on labour, particularly unskilled and semi-skilled labour, might be more appropriate.

3. Methodology

This project explores the use of basic construction material, labour and capital cost indices to develop a framework for evaluating the structure of the construction industry. A systematic approach based on the structure of construction inputs and outputs is proposed and applied to evaluate the industry-wide impact of changes in inputs on the performance of the industry. The framework is used to map the technology choices to various combinations of input cost indices in a number of developed and developing countries. The approach is to examine a number of countries with the availability of indigenous raw materials, high and low labour costs, and to show the price developments of production factors used in their respective construction industries.

3.1 Compilation of Basic Prices

Construction cost data from Australia, United Kingdom, Malaysia and the United States were obtained from their respective cost information or cost data services (Rawlinsons 2010, BCIS 2012, RSMeans 2012), or directly from a builder when no published data was available. In this pilot study, the investigation was limited to three concrete construction methods (conventional cast-in-place reinforced concrete, precast concrete, and pre-stressed concrete) and includes 4 countries (Australia, UK, Malaysia and US) to validate the research approach before proceeding to a more comprehensive examination of a wider range of structural systems and international coverage. Selecting a mix of developed and developing countries will allow a comparative analysis of the differences among and between the two groups of countries in terms of technology choice and its relationship with regards to construction costs. Due to difficulties in obtaining representative data from developing economies, the comparison is currently limited to one developing country.

3.2 Case studies of concrete systems

Three case studies were identified to represent the conventional cast-in-place reinforced concrete, precast concrete and prestressed concrete systems, respectively, in Melbourne, Australia. The cast-in-place system was utilised in a double storey (and a single basement) 2,405 square metre retail and office development at Balwyn. Only the ground and first floor concrete structures were considered for this building. The precast concrete case study was a double storey residential apartment at St.Kilda, previously reported by Yong (2010) providing a built-up area of 1,154 square metres. The pre-stressed concrete project was a single post-tensioned concrete slab in the upper level of 1,122 square metres for an office/industrial building at Noble Park.

Two separate analyses were conducted. The first analysis was to determine contractor's or builder's costs for one cast-in-place reinforced concrete building based on cost data in Australia, UK, Malaysia and US. This will allow a comparison of the various material costs, labour and plant constants, and the final structural system costs. The significance of the derived ratios described in section 3.1 will be discussed. The second analysis consists of a comparison of the three different systems in Australia and two systems in Malaysia.

4. Basic Prices and Derived Ratios

A selection of basic prices for these four countries is shown in Table 1 below in the respective local currencies. If these basic prices are compared based on currency exchange rates, it can be observed that labour rates and concrete costs are dependent on domestic factors whereas internationally traded commodities such as steel reinforcements and structural sections are linked to global prices. Labour rates in developed economies tend to be significantly higher than those in developing countries. Malaysia has routinely engaged a large number of construction workers from Indonesia and Bangladesh to support the local construction industry as the local labour force was reluctant to work in the industry (Abubakar, 2002). When these basic prices are presented as a ratio(e.g. one cubic metre of concrete/one day skilled worker wages), it is apparent that one cubic metre of concrete is worth 2.11 days wages in a low wage developing country as compared to 0.32 days wages in a high labour cost country such as Australia. The comparatively lower labour cost in Malaysia should motivate builders to adopt more labour intensive processes and to economise on concrete materials in their construction. The higher wage costs in a developed economy will evidently motivate builders to reduce their dependence on labour by adopting standard concrete element sizes even though these may result in a greater quantity of concrete.

Table 1: Basic prices and derived ratios

	Australia AUD	*Malaysia MYR*	*UK GBP*	*US USD*
Basic Prices				
Skilled Worker (per day)	*500*	*95*	*120*	*342*
Concrete (cu.m)	*158.55*	*200.85*	*94.95*	*134.40*
Steel Reinforcement (tonne)	*1,510*	*2,520*	*890*	*980*
Structural Steel (tonne)	*1,800*	*3,000*	*1,015*	*860*
Derived Ratios				
Concrete/Skilled Worker	*0.32*	*2.11*	*0.79*	*0.39*
Steel Reinf/Skilled Worker	*3.02*	*26.52*	*7.40*	*2.86*
Structural Steel/Skilled Worker	*3.60*	*31.57*	*8.44*	*2.51*
Skilled Worker/Concrete	*3.15*	*0.47*	*1.27*	*2.55*
Steel Reinf/concrete	*9.52*	*12.55*	*9.37*	*7.29*
Structural Steel/concrete	*11.35*	*14.94*	*10.69*	*6.40*
Skilled Worker/Steel Reinf	*0.33*	*0.04*	*0.14*	*0.35*
Concrete/Steel Reinf	*0.11*	*0.08*	*0.11*	*0.14*
Structural Steel/Steel Reinf	*1.19*	*1.19*	*1.14*	*0.88*

Note: AUD 1.00 = MYR 3.221, GBP 0.678, USD 1.073 in March 2012.

The difference for steel reinforcement is significantly greater where one tonne of steel reinforcement is equivalent to more than 26 days wages in Malaysia as compared to only 2.86 days in the US. The high relative cost of steel reinforcement in a developing economy will certainly ensure that steel reinforcements are used optimally whereas prefabricated steel systems such as the labour saving BAMTEC steel reinforcing carpets are increasingly being utilised in Australia. The ratio of steel reinforcement to concrete does not seem to differ as significantly as other ratios ranging from 7.29 in the US to 12.55 in Malaysia. A higher ratio should lead to a greater utilisation of deeper concrete sections with reduced steel reinforcement densities to achieve the same load carrying capacities. The next comparison of structural steel to concrete indicates that structural steel is relative cheap in the US as compared to Australia, UK or Malaysia. This is borne out by the anecdotal evidence of a greater number of structural steel buildings in the US as compared to these countries where there is a stronger tradition of concrete construction.

5. Cost of Concrete Systems

A summary of the rates and quantities for the cast-in-place reinforced concrete system is attached in Table 2. The rates were divided into basic material rates, and labour and plant constants to determine the approximate proportion of expenditure in each segment. As this study was focused on the main structural system, items such as the basement, roof, walls and other components of the building were not considered. When priced with local Melbourne rates, the materials consist of 50% of the total structural costs with labour and plant at 45% and 5%, respectively. This is comparable with both the UK and US prices where the split for material, labour and plant remain at approximately 43%-46%-11% and 45%-54%-1%, respectively. Plant and equipment cost ranges from 1% to 11% depending on the type of concrete conveyance system employed. Significant differences can be observed when the same project is priced based on rates obtained from a builder in Malaysia. The lower labour rates result in a lower proportion for labour at 22% with a corresponding material proportion at 72%.

A closer examination of the labour components indicates that the labour constant for installing steel reinforcements in the suspended slabs are extremely low at 0.01 for Australia and the US compared to 0.03 – 0.04 for the UK and Malaysia. Labour constants for placing concrete are again lower for Australia and the US compared to the UK and Malaysia. The analysis also indicates that labour intensive activities such as the installation and dismantling of formwork comprise a large proportion of the labour costs. In fact, the labour component of formwork exceeds the material costs due to multiple uses (up to 5) of the same formwork in the building. It is also pertinent to note that formwork consists of 47% to 65% of the total costs of cast-in-place concrete works in developed countries as opposed to 23% in Malaysia.

Based on this observation, it is not surprising that numerous innovative systems of precast concrete elements or lost formwork systems have been developed to reduce the utilisation of timber forms in reinforced concrete works in developed countries. Although labour is cheaper for a low wage country, formwork installation and dismantling costs are 65% of total labour and remains the largest component of the total labour requirements. However, it constitutes only 22% of the total concrete works whereas the materials make up a more significant 71%. Considering that labour only constitutes 22% of the total cost of concrete works, there is little incentive to employ more productive methods of construction.

Table 2 Cost of cast-in-place reinforced concrete buildings

No	Description	Unit	Quantity	All-in Rate	Amount	Material	Rate	Amount	Labour Constant	Hour	Rate	Amount	Plant Constant	Hour	Rate	Amount
RC Bldg	**AU Rates from Rawlinsons (2010)**															
100	**Slab**															
101	steel reinforcement (Y12,16)	kg	26,775	2.42	64,660.71		1.65	44,210.72	0.009	240.97	62.50	15,060.72	6.81E-04	18.24	170.00	3,100.03
102	concrete	cu.m	307.53	269.47	82,869.44		158.55	48,759.11	1.25	384.41	62.50	24,025.89	0.123	37.83	170.00	6,430.48
103	formwork (class 2)	sq.m	1,662.33	174.00	289,245.77		79.26	131,752.93	1.45	2,410.38	62.50	150,648.84	0.049	81.45	170.00	13,847.23
200	**Beam**															
201	steel reinforcement (Y20,24,28)	kg	11,305	2.42	27,301.21		1.51	17,038.87	0.011	124.35	62.50	7,772.08	6.81E-04	7.70	170.00	1,308.90
202	concrete	cu.m	208.69	269.47	56,234.89		158.55	33,087.32	1.25	260.86	62.50	16,303.67	0.123	25.67	170.00	4,363.65
203	formwork	sq.m	697.36	176.00	122,735.55		75.40	52,581.03	1.53	1,066.96	62.50	66,685.16	0.050	34.87	170.00	5,927.57
300	**Column**															
301	steel reinforcement (Y24,R10)	kg	7,971	2.42	19,250.47		1.51	12,014.29	0.011	87.68	62.50	5,480.21	6.81E-04	5.43	170.00	922.93
302	concrete	cu.m	39.89	310.96	12,404.38		158.55	6,324.56	1.80	71.80	62.50	4,487.63	0.134	5.35	170.00	908.69
303	formwork	sq.m	309.96	220.00	68,191.20		79.85	24,750.31	2.07	641.62	62.50	40,101.08	0.062	19.22	170.00	3,266.98
	Structure (cost per sq.m, %, total)		**308.90**	**100%**	**742,893.62**	**154.06**	**50%**	**370,519.13**		**137.45**	**44%**	**330,565.27**		**16.66**	**5%**	**40,076.45**
RC Bldg	**UK Rates from BCIS (2012)**															
100	**Slab (185mm thk)**															
101	steel reinforcement (Y12,16)	kg	26,775	1.43	38,287.71		0.89	23,829.41	0.04	1,070.98	15.04	16,107.61	-	-	-	-
102	concrete	cu.m	307.53	128.04	39,376.32		94.95	29,200.11	2.20	676.57	15.04	10,175.60	-	0	-	-
103	formwork	sq.m	1,662.33	33.25	55,269.88		6.13	10,189.76	1.44	2,393.76	14.25	34,111.05	3.00	4,987.00	2.20	10,971.39
200	**Beam (800-2400 wide)**															
201	steel reinforcement (Y20,24,28)	kg	11,305	1.22	13,791.91		0.85	9,609.12	0.03	339.15	15.04	5,100.75	0	-	2.20	-
202	concrete	cu.m	208.69	147.60	30,802.20		94.95	19,814.83	3.50	730.40	15.04	10,985.28	0.00	-	-	-
203	formwork	sq.m	697.36	87.83	61,248.95		11.73	8,177.67	3.0768	2,145.64	16.15	34,652.10	12.00	8,368.33	2.20	18,410.33
300	**Column**															
301	steel reinforcement (Y24,R10)	kg	7,971	1.17	9,326.31		0.84	6,695.82	0.02	159.42	15.04	2,397.74	0	-	2.20	-
302	concrete	cu.m	39.89	170.16	6,787.68		94.95	3,787.56	5.00	199.45	15.04	2,999.73	0	-	-	-
303	formwork	sq.m	309.96	32.30	10,011.15		5.45	1,689.28	0.975	302.21	14.25	4,306.51	2.5	774.90	4.44	3,440.56
	Structure (cost per sq.m, %, total)		**110.15**	**100%**	**264,902.12**	**46.98**	**43%**	**112,993.56**		**50.24**	**46%**	**120,836.37**		**13.65**	**11%**	**32,822.28**

Table 2 Cost of cast-in-place reinforced concrete buildings (continued)

	No	Description	Unit	Quantity	All-in Rate	Amount	Material	Rate	Amount	Labour Constant	Hour	Rate	Amount	Plant Constant	Hour	Rate	Amount
RC Bldg		**MY Rates**															
	100	**Slab (185mm thk)**															
	101	steel reinforcement (Y12,16)	kg	26,775	2.90	77,764.21		2.52	67,472.05	0.03	803.24	11.88	9,542.48	7.00E-05	1.87	400.00	749.69
	102	concrete	cu.m	307.53	246.04	75,664.26		200.85	61,767.69	2.05	630.44	9.75	6,146.78	0.063	19.37	400.00	7,749.79
	103	formwork	sq.m	1,662.33	26.07	43,337.00		9.07	15,077.35	1.50	2,493.50	10.00	24,934.98	0.01	8.31	400.00	3,324.66
	200	**Beam (800-2400 wide)**															
	201	steel reinforcement (Y20,24,28)	kg	11,305	2.90	32,833.80		2.52	28,488.22	0.03	339.15	11.88	4,029.05	7.00E-05	0.79	400.00	316.54
	202	concrete	cu.m	208.69	246.04	51,344.83		200.85	41,914.78	2.05	427.81	9.75	4,171.13	0.06	13.15	400.00	5,258.91
	203	formwork	sq.m	697.36	39.77	27,730.56		10.31	7,189.79	1.70	1,185.51	16.15	19,146.05	0.01	3.49	400.00	1,394.72
	300	**Column**															
	301	steel reinforcement (Y24,R10)	kg	7,971	2.90	23,151.58		2.52	20,087.45	0.03	239.14	11.88	2,840.94	7.00E-05	0.56	400.00	223.19
	302	concrete	cu.m	39.89	246.04	9,814.44		200.85	8,011.91	2.05	81.77	9.75	797.30	0.06	2.51	400.00	1,005.23
	303	formwork	sq.m	309.96	34.14	10,582.03		11.14	3,452.95	1.90	588.92	10.00	5,889.24	0.01	3.10	400.00	1,239.84
		Structure (cost per sq.m, %, total)		**146.45**	**100%**	**352,222.71**	**105.39**	**72%**	**253,462.18**		**32.22**	**22%**	**77,497.95**		**8.84**	**6%**	**21,262.58**
RC Bldg		**US Rates from RSMeans(2012)**															
	100	**Slab (185mm thk)**															
	101	steel reinforcement (Y12,16)	kg	26,775	1.59	42,571.65		1.05	28,113.35	0.01	294.52	49.00	14,431.52	-	-	-	-
	102	concrete	cu.m	307.53	160.40	49,328.04		134.40	41,332.22	0.52	160.53	37.75	6,060.06	1.00	307.53	6.30	1,937.45
	103	formwork	sq.m	1,662.33	50.63	84,163.87		11.07	18,402.02	0.93	1,537.66	42.80	65,811.72	-	-	-	-
	200	**Beam (800-2400 wide)**															
	201	steel reinforcement (Y20,24,28)	kg	11,305	1.96	22,157.50		0.98	11,078.75	0.02	226.10	49.00	11,078.75	-	-	-	-
	202	concrete	cu.m	208.69	180.80	37,730.61		134.40	28,047.53	0.93	193.66	38.00	7,359.14	1.00	208.69	11.16	2,328.95
	203	formwork	sq.m	697.36	88.37	61,622.31		12.04	8,396.23	1.79	1,244.79	42.80	53,276.99	-	-	-	-
	300	**Column**															
	301	steel reinforcement (Y24,R10)	kg	7,971	1.67	13,272.06		0.98	7,811.79	0.01	111.60	49.00	5,468.25	-	-	-	-
	302	concrete	cu.m	39.89	179.30	7,152.28		134.40	5,361.22	0.91	36.30	37.40	1,357.62	1.00	39.89	10.96	437.19
	303	formwork	sq.m	309.96	69.45	21,526.72		8.17	2,532.37	1.46	453.16	42.00	19,032.78	-	-	-	-
		Structure (cost per sq.m, %, total)		**141.17**	**100%**	**339,525.04**	**62.82**	**44%**	**151,075.48**		**76.46**	**54%**	**183,876.84**		**1.96**	**1%**	**4,703.59**

A further analysis into the three different structural concrete systems in Australia is shown in Table 3. The cost for the cast-in-place reinforced concrete system was calculated as AUD 309 per square metre. The proportion for material, labour and plant was 50%, 45% and 5%, respectively. The cast study with a precast concrete system, which consists of precast prestressed hollowcore planks, precast inverted-T beams and precast columns resulted in a 9% higher cost at AUD 336 per square metre. The material cost has increased to AUD 207 due to higher manufacturing and transportation costs for the precast elements, but there is a consequential reduction in onsite labour costs for the assembly of these elements. The plant costs have increased nearly three-fold due to the necessity of a larger capacity crane for the assembly process.

Table 3: Unit cost (per square metre) of different structural systems in Australia and Malaysia

	Total	*Material*	*Labour*	*Plant*
Australia (in AUD)				
Cast-in-place Reinforced Concrete	*309*	*154 (50%)*	*138 (45%)*	*17 (5%)*
Precast planks, beams and columns	*336*	*207 (62%)*	*85 (25%)*	*44 (13%)*
PT slabs, beams and RC columns	*388*	*235 (61%)*	*152 (39%)*	*n.a.*
Malaysia (in MYR)				
Cast-in-place Reinforced Concrete	*146*	*105 (72%)*	*32 (22%)*	*9 (6%)*
Precast planks, beams and columns	*384*	*336 (88%)*	*21 (6%)*	*26 (7%)*
PT slabs, beams and RC columns	*n.a.*	*n.a.*	*n.a.*	*n.a.*

An alternative cast-in-place concrete system which is commonly utilised in Melbourne is post-tensioned (PT) slab and beam. This usually results in thinner structural sections, reduced steel reinforcements quantities, simpler steel layout, reduced deflections or greater spans in the structure. However, the PT slab and beam system requires extensive engineering input and higher technical skills to achieve a satisfactory solution. When compared to the conventional reinforced concrete system, the PT slab and beam solution is 25% more costly on a per square metre basis. The prestressing tendons are significantly more expensive (approximately 2.5 times the as-installed cost on a per ton basis) compared to the steel reinforcements, but a smaller quantity is normally required as the tendons are highly stressed. The material and labour costs are AUD 235 and AUD 152 per square metre, respectively. The high labour component is again indicative of the high cost of labour to erect scaffolding and formwork.

A similar comparison of the cast-in-place and precast system in Malaysia yields very interesting results. There is an analogous increase in total cost when a precast system in utilised in place of the conventional reinforced concrete system. This is to be expected as the cost of precast elements are expected to be higher than cast-in-place elements due to additional connecting elements and increased cost of transportation and handling. A comparable decrease in site labour, that is to be expected, is also observed. The remarkable difference is in the sizeable increase in material cost for precast elements in Malaysia. The material cost for precast was shown to be three times the cost of cast-in-place materials whereas the precast elements in Australia were only 34% more expensive. This resulted in a total system cost that was 163% higher than the conventional system, negating any obvious advantages in speedier construction, increased productivity or improved quality with precasting.

The derived ratios for concrete/skilled worker and steel reinforcement/skilled worker indicate clearly that concrete and steel reinforcements are relatively cheap compared to the cost of labour in both the US and Australia. It is apparent that with a concrete/skilled worker ratio of 2.11, and steel reinforcement/skilled worker ratio of 26.52, it is more economical to adopt conventional cast-in-place concrete practices instead of precast systems. This study has also shown that similar ratios of 0.32 and 3.02, respectively, will lead to a precast system cost that is only marginally higher than cast-in-place systems, and the additional benefits of quicker construction, better control over quality, and reduced exposure to weather risk can be achieved.

6. Conclusions and Further Work

The construction cost – construction technology choice approach identified in this project may provide the context for the choice of construction technology. While the focus is initially concerned with reinforced concrete methods of construction, the derived ratios may be extend to inform on a wide range of construction choices, either locally developed or imported from overseas, available to developing economies. A working cost-technology model will provide the construction industry with a much needed tool to evaluate the most appropriate options to deliver residential, commercial and institutional buildings, especially for rapidly developing economies facing constraints of labour, capital or resources.

The small set of derived ratios based on skilled worker wages, and basic construction materials such as concrete, steel reinforcements and structural steel is able to adequately rationalise the choice between cast-in-place and precast systems of construction. The large material/skilled worker ratios for a developing country like Malaysia clearly highlight the motivation to economise on construction materials instead of investing in labour reducing processes. Conversely, the developed economies of Australia, UK and the US will attempt to reduce the use of labour by investing in industrialised building systems.

Future work will focus on obtaining additional project cost data for the three concrete structural systems in Malaysia, UK and the US to enable a similar comparison to be made. This research project is part of a broader study to determine derived ratios to develop a framework to analyse a wider range of construction technologies.

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Improving a Cost Estimate using Reference Class Analytics

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Abstract

Cost estimating is riddled with uncertainties – designs change, clients vacillate, economies cycle, markets fluctuate. Current cost estimating practice relies on a detailed analysis of the building works, contractor levies, design fees, project-specific costs, risks, contingencies and market conditions particular to a given project proposal. Despite decades of technical refinement, extensive data collection, cost modelling research and improved risk management, the accuracy of a cost estimate today appears to be no better than it ever was.

Analytics involves making more effective use of the vast and increasing volume of data now available through digital networks. Analytics is an emerging discipline that uses various data-mining and statistical techniques to extract knowledge from data. Critical in the context of this paper, whereas current cost estimating practice looks to analyse a particular project proposal from the inside, analytics provides a perspective from the outside. The two approaches are complementary.

This paper presents an analysis of 228 relatively homogenous construction projects undertaken for the same client over several years to demonstrate the extent of the potential uncertainty in current cost estimating practice. Cost variation from the initial approved budget estimate to final outturn cost ranged from -44% to +165%, with an average budget overrun of 5.12% and a coefficient of variation of 17.47%. A review of the literature indicates that such figures are not abnormal. In hind-sight there is often good reason for the variation. This paper argues that variations of that extent are unlikely to be managed out of a typical building construction project, but that the potential for such variation is actually quite predictable. An analytics approach to cost estimating termed Reference Class Analytics is proposed and shown to improve the validity of the estimate (and performance of the estimator). Limitations and potential unintended consequences of this approach are discussed.

Keywords: Cost estimating, Accuracy, Precision, Reference class analytics

1. Introduction

The cost estimate for any building project is a complex thing, both in practice and in principle. In practice it is complex because it uses different techniques in different forms at different stages of a project development, with different purposes, different variables and different levels of accuracy. In principle it is complex because it relies on both statistical data and expert opinion to forecast the combined outcome of a unique project in a unique situation at a unique point in time.

Such complexity is exacerbated by the lack of a definitive description of the building process itself, which frames how the cost estimate is supposed to operate. There are certainly such frameworks as the broad RIBA Plan of Work, which is most often referenced (see for example Smith and Jaggar, 2007), or the more specific aspects of cost planning practice developed to contain and control those design, procurement and construction decisions that directly impact project cost (Ferry et al, 1999). But such frameworks are rather generic and often fail to reflect changes in industry and procurement practices. This is important, because the outcome of any cost estimating process depends greatly on how it is framed. Different stakeholders tend to interpret and understand the cost estimating problem often in quite radically different ways. Compare, for example, the different perspectives of the cost planner to the builder's estimator, or the budget estimate to the tender estimate. In these and other critical ways, cost estimating very much characterises what Rittel and Webber (1973) termed a 'wicked problem'.

Wicked problems cannot be resolved effectively using only a prescriptive sequence of analysis and rationalistic methods. Wicked problems are dialectically constituted (Lave, 1988), meaning that they are formed (in a fundamental sense) through the act of definition and description itself. They are not something absolute (in the pre-existing sense) that we merely discover or reveal. Considered in terms of a wicked problem, a valid cost estimating process must negotiate the combination of bottom-up (rationalist) constituents as well as top-down (interpretive) contexts. In broad scope, a valid estimate needs to be accurate and precise. One key challenge for cost estimating practice (taken as a wicked problem) is to improve accuracy and precision through better management of the bottom-up and top-down combination process.

This study sets out to demonstrate that the accuracy and precision of a cost estimate is improved by increased emphasis on top-down context factors. It defines accuracy as the closeness of the estimate forecast to the actual outturn cost. It defines precision as the spread of the results over repeated projects. In other words, accuracy equates to proximity and precision equates to variability (see Figure 1). Skitmore (1991) also refers to accuracy as bias and to precision as consistency.

Bottom-up constituents are those factors specific to a particular project, such as the gross floor area, quality of finishes proposed, prevailing market conditions, project-specific risks and client. Top-down contexts are those factors that characterise a particular project within a related class of such projects (the Reference Class), such as the project scale, type of building, likely estimating accuracy, and reference class analytics. Reference Class Analytics is introduced here as a new term for the various insights and overviews derived through systematic analysis of broad-based reference class data. Reference Class Analytics provides the particular focus for this study.

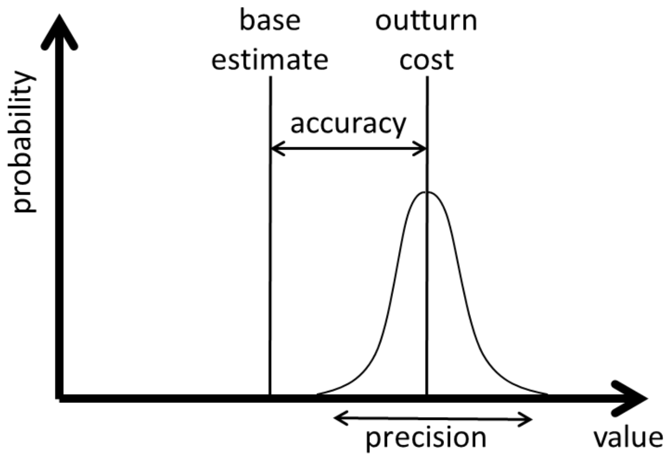

Figure 1: The Accuracy and Precision of an Estimate

2. The Accuracy and Precision of an Estimate

A cost estimate forecast can be accurate but not precise, precise but not accurate, neither, or both. For example, if the estimate for a building project is expressed as being somewhere between A$1M and A$10M, and the actual outturn cost is $5M, then the estimate was accurate but far from being precise. On the other hand, if the estimate for that same project is expressed as exactly A$2M and the outturn cost is again $5M, then on this occasion the estimate was precise but far from accurate.

The most common practice in building construction estimating is to provide single figure (very precise) cost estimates, even at a project stage where there are a multitude of uncertainties applicable. We all understand that designs change, clients vacillate, economies cycle, markets fluctuate. The RICS New Rules of Measurement, however, even for early stage Order of Cost estimates, presumes that all estimates are expressed as single (precise) figures (RICS, 2012). Ashworth (2008, p.251) sets out the various levels of cost estimating accuracy achieved using single figure estimates at different stages of a project, across all construction types (see Table 1).

Table 1: Estimate Classification and Accuracy (from Ashworth, 2008, p.251)

Estimate	Purpose	Accuracy
Order of magnitude	*Feasibility studies*	25-40%
Factor estimate	*Early stage assessment*	15-25%
Office estimate	*Preliminary budget*	10-15%
Definitive estimate	*Final budget*	5-10%
Final estimate	*Prior to tender*	5%

Table 1 illustrates how at the earliest project stage there is the maximum potential discrepancy (inaccuracy) between the cost estimate and the final project cost. According to Ashworth (2008), that discrepancy is typically between 25% and 40%. Naturally, the accuracy of the estimate is shown to improve as the project develops and the project design and specification is better resolved. For example, at the stage immediately prior to tender the level of accuracy is listed as 5% – meaning a 5% discrepancy. However, these figures are indicative only. The figures may be based on empirical research, but research to date has lacked consistency in what actually is being estimated: is it the lowest tender price, the total construction costs, or the overall project outturn costs. A review by Liu and Zhu (2007: p.91) claims that studies on cost estimating accuracy date back to the 1970s and indicate that the general level of accuracy has "hardly changed over the past 4 decades and remains at around 10% level". But such a claim belies the actual variability (lack of consistency) between the studies, the quality of the data and the different purposes of the analyses.

A study by Skitmore and Picken (2000) analysed the accuracy of 217 pretender estimates against the lowest tender values. Overall, the estimates had an accuracy of 5.19%, but that figure varied by as much as 7.82% (coefficient of variation). Against all comparable studies, that is shown to be a strong performance – ranking 5th out of the 24 studies considered (See Skitmore and Picken, 2000: p.34). It also appears to accord nicely with the 5% accuracy level listed in Table 1. However, "a 5.19% average and 8.23% [sic] coefficient of variation implies that estimates are only correct to within 12.12% below and 22.50% above the lowest bid price for 19 out of 20 projects" (Skitmore and Picken, 2000: p.38). It seems clear that estimate forecasts, even at the late pre-tender stage of a project, compared only against the lowest tender figure and not final outturn cost, and taken for one of the better performing organisations, would generally fail even basic expectations of validity.

The Skitmore and Picken (2000) analysis went further, to review the variation in the accuracy (mean error) and precision (standard deviation) depending on the project type, project size, year, and sector (public, private or military). It revealed significant difference in forecasting accuracy in terms of project size and year, and significant difference in forecasting precision in terms of project type, project size and year. The analysis also revealed significant confounding effects. When the effects of the year were partialled out, this removed all the significant effects of other variables. In other words, for that data sample, the accuracy of the estimates is directly correlated to the particular year of the estimate. Further analysis then showed a positive correlation (slightly offset) between accuracy and the rate of inflation.

A broader-based review of factors by Aibino and Pascoe (2008), used data from 56 projects to analyse project size, location, procurement, project type, structural material and price intensity. Price intensity is the total cost of a building divided by the gross floor area. Gunner and Skitmore (1999: p.274) hypothesised that low price intensive buildings will tend to be overestimated more than high price intensive buildings. The findings of Aibino and Pascoe (2008) broadly confirmed the general lack of accuracy and precision, the potential confounding impact of inter-correlated factors, a lack of improvement in performance over time, and significant variation in accuracy and precision across different project factors. Whilst not a basis for strong conclusions, the Aibino and Pascoe (2008) data did not support the Gunner and Skitmore (1999) price intensity hypothesis.

This brief consideration of the accuracy and precision of an estimate has highlighted a number of issues. First and foremost, empirical research indicates that the conventional wisdom on estimating accuracy, as represented in Table 1, is broadly correct but misleading. Current estimate forecasts are failing the basic tests of validity – accuracy and precision. Secondly, whilst a range of project factors correlate with the accuracy and precision of an estimate, there is strong evidence that inter-correlations are confounding those effects. There would appear some reason to focus attention on the possibility that a single principal factor, such inflation or price intensity, could usefully serve to improve the overall accuracy and precision of an estimate. Finally, the optimum choice of a single principal factor is not yet clear. The choice might vary depending on project type, scale, etc. The most immediate choice of factor (such as year) might ultimately be better substituted with an equivalent external statistical analysis of factors (such as the rate of inflation).

This study will further evaluate the potential for such external analytics, taken as broad statistical data derived from a reference class of previous work, to improve the validity of a cost estimate – Reference Class Analytics.

3. Reference Class Analytics

The data set for this study comprises 228 mixed construction projects ranging in value from A$100K to A$32M. The projects were commissioned and audited by the same client over a 10 year period using a standardised project closure reporting system. This provides for a consistent definition of the estimate and the outturn cost. The estimate used is taken as the total approved budget (Estimate) value. The outturn cost used is taken as the total actual cost (Actual) of the project. The difference between the Estimate and the Actual indicates the accuracy of the Estimate. A negative difference indicates a reduction (saving) in Actual versus Estimate, and therefore implies an over-estimate. A positive difference indicates an increase (additional cost) in Actual versus Estimate, and therefore an implied under-estimate.

Each difference between the Estimate and Actual is expressed as a percentage of the Estimate to represent the variation. Figure 2 shows the frequency distribution for the percentage of variation as calculated. The mean of this variation (accuracy) is calculated at 5.12%. This provides evidence from the data that the outturn cost (Actual) is being underestimated by a factor of slightly more than 5%. On the surface, a value of 5.12% might appear rather low (more accurate) compared to the 10-15% expected for a preliminary budget estimate in Table 1. However, the 5.12% figure then ranges by an average of 17.47% (the coefficient of variation), which actually renders the Estimate overall as a highly imprecise value.

It is also evident from Figure 2 that the distribution of variations around the mean is not balanced or normal, but rather skewed positively to the right. This reflects the fact that there is a 2:1 chance that the Actual costs will be underestimated. In statistical terms, the estimated costs are biased and the bias is caused by systematic underestimation. This is a very characteristic distribution of the variation between Estimated and Actual costs. Figure 3 presents an equivalent (and remarkably similar) distribution derived from an analysis of 258 transportation infrastructure projects undertaken by Flyvbjerg et al. (2002).

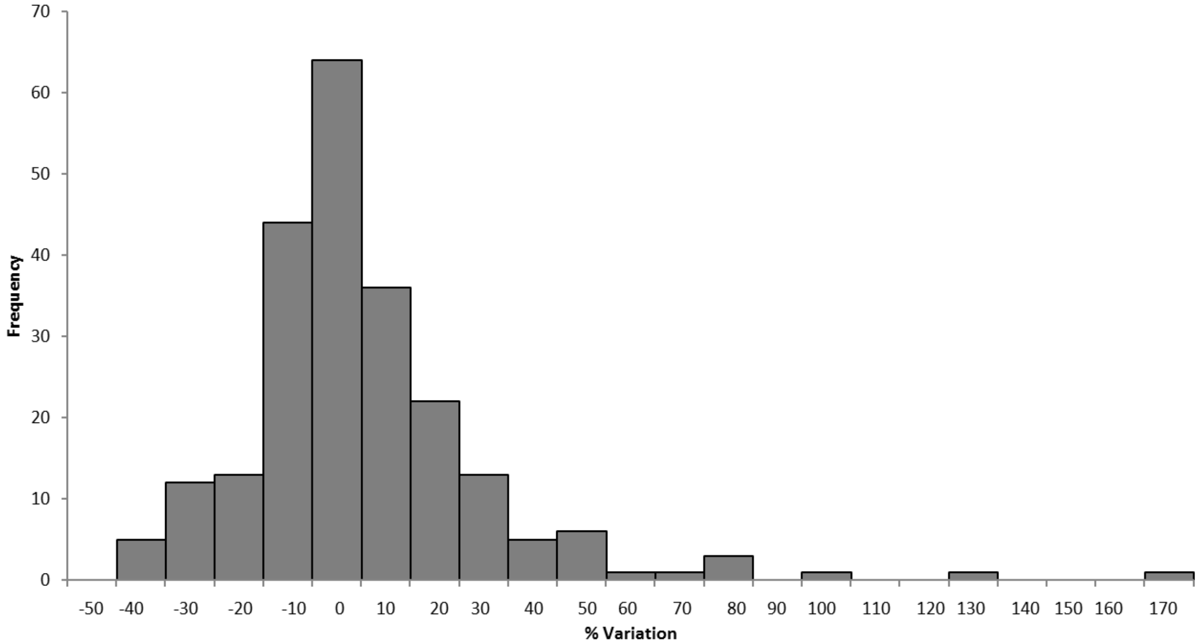

Figure 2: *Frequency Distribution of Variation between Estimate and Actual*

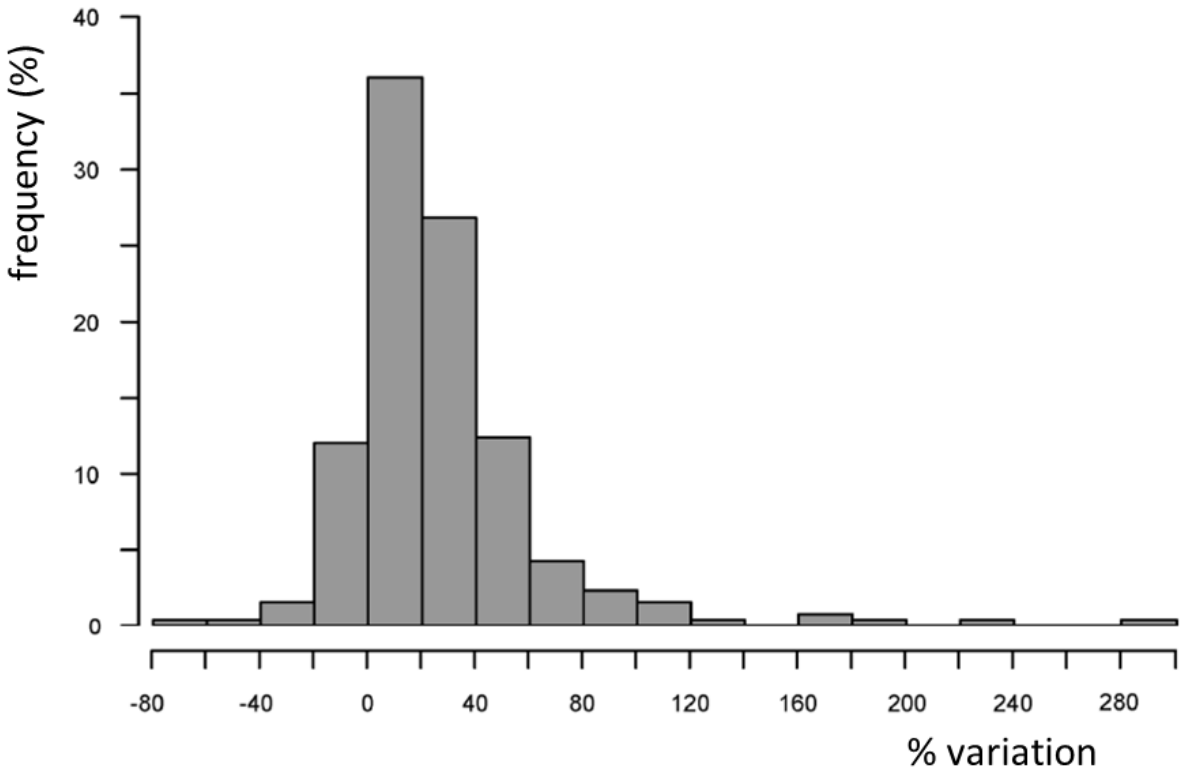

Figure 3: *Inaccuracy of cost estimates in 258 transportation infrastructure projects*
(Source: Flyvbjerg et al, 2002: p.283)

On the basis of several such analyses, Flyvbjerg (2008) proposes the use of an adjustment percentage. For the current data set, the average underestimate overall is 5.12%. This implies that the accuracy of any future Estimate for the current client would be improved significantly simply by adding a factor of 5.12% to each Estimate. As detailed in the RICS New Rules of Measurement (RICS, 2012), the Estimate would still require a bottom-up calculation of the base cost estimate, adjusted for the project/design team fees and other development/project costs. To the base cost estimate would then be added risk allowances for design development risks, construction risks, employer change risks and other employer risks. Finally an allowance would be added for the tender inflation estimate and construction inflation estimate. It is to this overall cost limit that an additional 5.12% should be added to improve significantly the accuracy of the Estimate in future.

Unfortunately whilst the overall accuracy would improve, the precision of the estimate would not. Had 5.12% been added to all previous projects at the time, the overall discrepancy between Estimate and Actual would have been reduced to 0.005%. The level of imprecision however, would have remained very high at 16.62% (the coefficient of variation). This is the 'flaw of averages' discussed by Savage (2009) and illustrated with some humour in Figure 4.

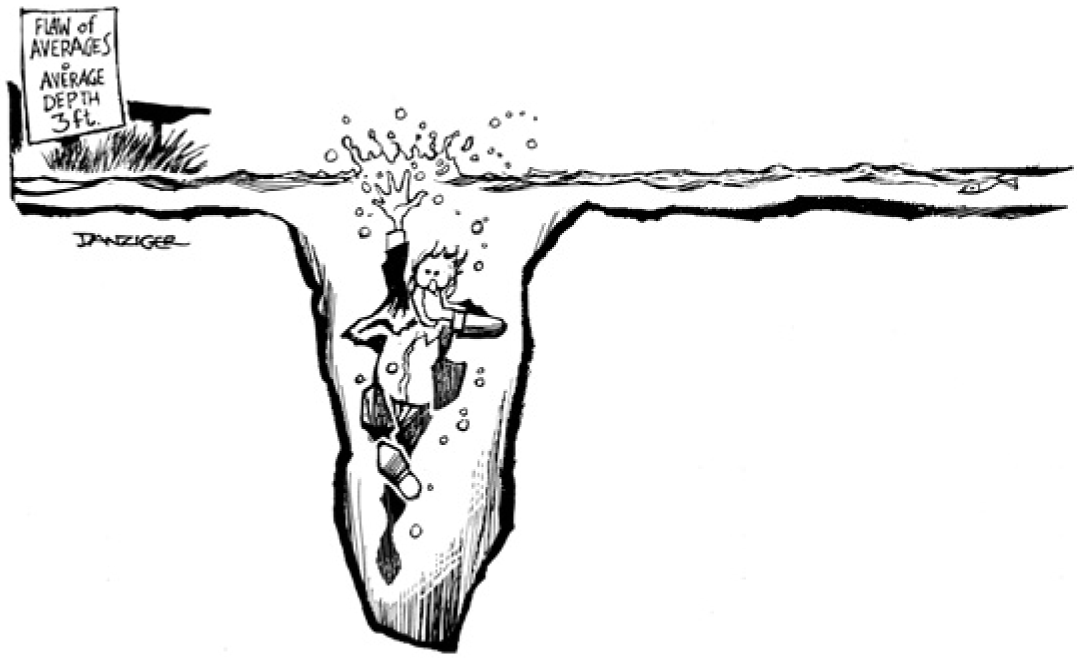

Figure 4: The Flaw of Averages
(Source: Savage, 2009: p.12)

The solution to this problem being advocated by Flyvbjerg (2008) is to use a cumulative distribution and to select a percentage addition commensurate with the level of risk aversion required. The cumulative frequency distribution for the current data set is provided in Figure 5. The distribution shows the cumulative probability against the percentage variation associated with that probability. For example, the average percentage variation remains 5.12% and this charts against the 50% probability. On the distribution is also marked the probability of an overestimate at 32.89%, meaning 32.89% of Estimates are overestimates. The P90 value indicates the point at which the probability of an Estimate being an overestimate is 90%. In other words, the addition of 32.75% is required over and above the overall cost limit otherwise calculated. Given such an addition, the expectation is that that 90% of future projects would come in at or under budget – Actual equal or less than Estimate.

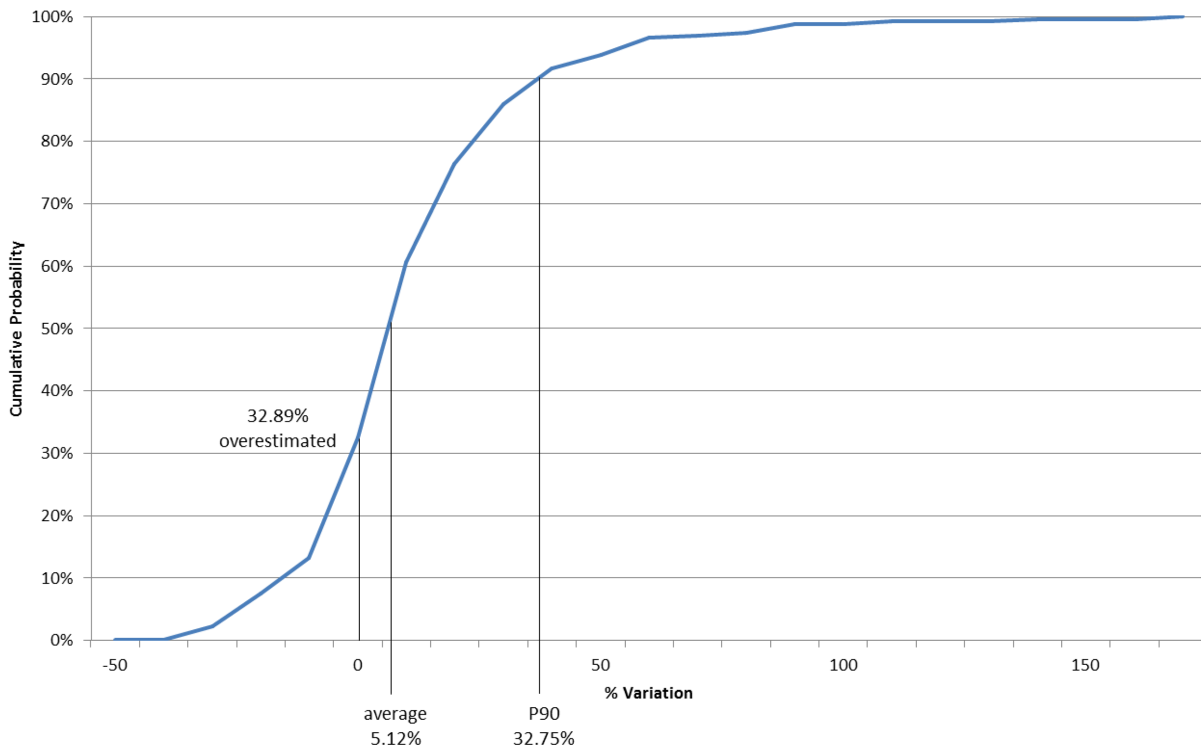

Figure 5: Cumulative Frequency Distribution for the Variation between Estimate and Actual

4. Discussion and Conclusions

Cost estimating is riddled with uncertainties – designs change, clients vacillate, economies cycle, markets fluctuate. Current cost estimating practice relies on a detailed analysis of the building works, contractor levies, design fees, project-specific costs, risks, contingencies and market conditions particular to a given project proposal. Whilst there are always broader considerations brought to bear, this is a bottom-up, rationalistic approach. Despite decades of technical refinement, extensive data collection, cost modelling research and improved risk management, the accuracy of a cost estimate today appears to be no better than it ever was. Indeed there is some suggestion that current estimating practice is no longer valid in terms of accuracy and precision. If it is reasonable to view estimating as a wicked problem, and it does exhibit the characteristics of a wicked problem, then the bottom-up constituents alone are not sufficient. An increased focus on the complementary, top-down contextual factors is being called for.

A review of key studies into estimating accuracy illustrates the lack of a common framework for how estimating is to be considered. This lack is significant. Various figures for accuracy conflate different types of estimates, different target costs and different aspects of accuracy and precision. On the surface, estimating accuracy appears relatively consistent with expectations. However, this belies the underlying impact of poor, and potentially worsening, precision. Correcting for systematic error should be reasonably straight forward. Applying an appropriate adjustment factor will shift the distribution of variations and result in significant gains in accuracy. Unfortunately, fixing the accuracy in this way does little to improve the precision of estimating practice. Both accuracy and precision are required to render an estimate valid.

Reference Class Analytics has been proposed as one effective means of balancing bottom-up constituents with top-down context factors. Adopting a Reference Class Analytics approach, the Estimate to Actual cost variations on 228 relatively homogenous projects has been analysed. A characteristically skewed distribution indicating reasonable accuracy but little precision has been generated. Of itself, this frequency distribution provides a useful (necessary) empirical basis for correcting the systematic error (bias) evident in the data. It does little more than highlight the lack of precision however.

When the analysis is reconfigured as a cumulative probability distribution it better serves the precision issue. The cumulative probability distribution provides an immediate measure of just how skewed the variations are towards underestimating. Just 32.89% of projects are overestimated, compared to 67.11% of projects that are underestimated. The same distribution puts an immediate figure on the systematic error, and what mark-up would be required to neutralise that bias. In this case an addition of 5.12%. Finally, the cumulative probability distribution provides a direct reckoning of the mark-up required to accommodate specific risk exposures. The current client is operating at a P32.89, meaning there is only a 32.89% chance that the budget estimate will be sufficient to cover the actual outturn costs of any project. A more risk averse client might require a P90, where 90% of projects would come in on or under budget. Of course the additional mark-up required to ensure such an outcome, 32.75% on top of the otherwise best budget estimate (including all risk and contingency allowances), might also make many projects unviable or lock a significant amount of additional capital into the system.

Without doubt, the ideal solution is to better manage and control projects so that costs are reduced and the factors that lead to cost blow-outs are mitigated. That should always be a priority. However, the nature of construction is such that there will always be uncertainty, and with uncertainty comes imprecision. There is actually no real excuse for the levels of ongoing inaccuracy we observe in current estimating practice. Reference Class Analytics provides a ready solution to that. Lack of precision is another matter. The changing economic, social, technical and environment context for construction is likely only to exacerbate that particular problem. Here Reference Class Analytics also has an important role to play, but more in the effective management of the risk exposure than in solving the problem.

This study confirms what every other equivalent study has always found to be the case – that the outturn cost of construction is systematically greater than our best estimates. Despite improved technique and extensive databases, despite our best efforts to identify and allow for risks, despite including generous levels of contingency, despite allowances for inflation and every other potential uncertainty, we consistently and significantly underestimate the final outturn costs of our projects.

Surely it is time to recognise and seek to address that failure. Reference Class Analytics provides one useful approach to solving the lack of accuracy and better managing the lack of precision.

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Evolution of Quantity Surveying Practice in the Use of BIM – the New Zealand Experience

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Abstract

The research reported in this paper investigated the current state of evolution of quantity surveying practice in New Zealand (NZ) in the use of BIM. Following a literature review that included surveys by others of BIM usage in NZ a form of purposive non-random sampling was used to identify and interview people considered by the NZ industry to be at the leading edge of practice. It was found that where BIM modelling is being practiced on larger projects in NZ it is generally at level 1 or 2 as defined by Bew and Richards' maturity model (2008). In this environment it is not necessary for quantity surveyors to change existing practices as they can continue to measure from 2D drawings derived from the 3D model. Only one instance of a QS firm measuring directly from the 3D model was found. Derivation of quantities from 3D models and linking of object quantities with costing rates contained within rate libraries is possible using estimating software that is available in NZ however this has not happened to date. Barriers to this practice being adopted are the need to develop description and coding systems and the need for the firms to develop formal libraries.

Keyword: Building Information Modelling, Cost Modelling, 5D, Quantity Surveying

1. Introduction

As the use of Building Information Modelling (BIM) technologies has moved from the research and development arena into commercial use differences are emerging between the aspirations of the BIM concept and the realities of commercial practice. This paper is focussed on how 5D (cost related) practices are emerging in New Zealand.

The BIM concept (or aspiration) is one of a single data rich model from which information can be drawn by the various parties involved in the buildings life cycle. The American General Contractors 2006 definition of BIM is a fairly typical example of this aspiration:

> *Building Information Modelling is the development and use of a computer software model to simulate the construction and operation of a facility. The resulting model, a Building Information Model is a data rich, object oriented, intelligent and parametric representation of the facility from where views and data appropriate to various users' needs can be extracted and analysed to generate information that can be used to make decisions and improve the process of delivering the facility (p5).*

Part of this data rich concept is that BIM should be able to support and record the cost modelling and cost management dimension (5D) of the design and construction process. This paper seeks to report current developments in this area of 5D modelling within New Zealand.

2. Literature Review

The purpose of this section is to provide a brief overview of current practice with BIM particularly in the area of 5D taken from the international literature. This review both served to inform the focus of the investigation of practice in New Zealand and to provide a basis for comparison. The review is broken into three sections, the extent of BIM usage, model building practice and 5D BIM.

2.1 BIM Usage

Internationally the use of BIM appears to be growing. McGraw Hill (2009) reported that 48% of respondents to a survey were using BIM, up from 27% in 2007. A more recent survey in the UK by the RIBA owned NBS (2012) found that 31% of construction professionals were using BIM up from 13% in 2010. An Australian Survey in 2010 found that 60% of Architects and 26% Engineers said they used BIM on more than 60% of their projects (Allen Consulting Group 2010). Surveys of this nature inherently provide little information on the depth of use of BIM. In some jurisdictions usage is being given impetus by government mandating of BIM, the US Government Services Agency did so in 2007 (GSA 2007) more recently the UK Government has issued a requirement for government funded projects of "fully collaborative BIM level 2 (with all project and asset information, documentation and data being electronic) as a minimum by 2016" (UK Cabinet Office 2011) (see below for description of levels).

The British Standards Institute (BSI) has adopted a useful maturity model developed by Bew and Richards (2008 cited in BIM Industry Working Group 2011) which illustrates that BIM practice can cover a broad spectrum (figure 1 below).

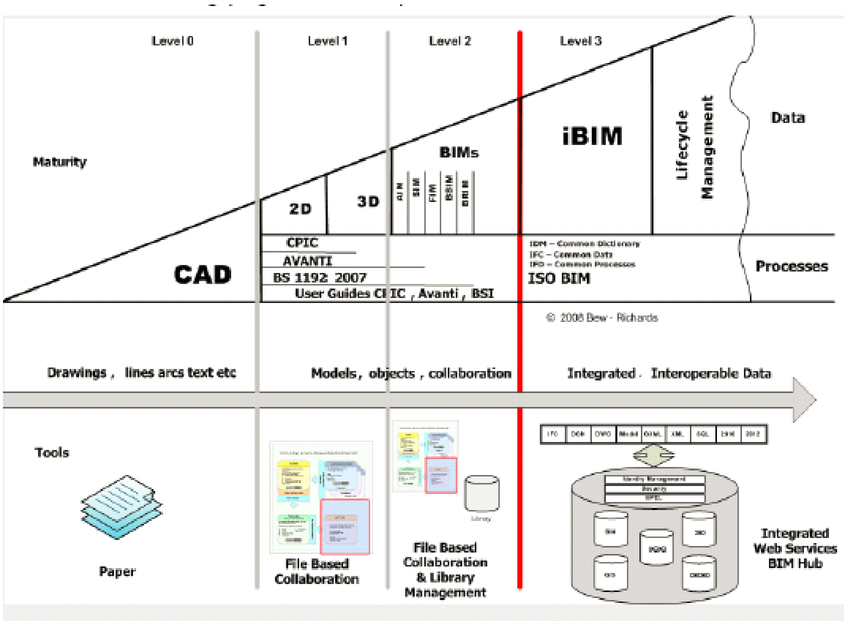

Figure 1. Bew & Richards 2008 as cited in BIM Industry Working Group (2011) p16.

Level Definitions

0. Unmanaged CAD probably 2D, with paper (or electronic paper) as the most likely data exchange mechanism.
1. Managed CAD in a 2D or 3D format using BS1192:2007 with a collaboration tool providing a common data environment, possibly some standard data structures and formats. Commercial data managed by standalone finance and cost management packages with no integration.
2. Managed 3D environment held in separate discipline “BIM” tools with attached data. Commercial data managed by an ERP. Integration on the basis of proprietary interfaces or bespoke middleware could be regarded as ‘pBIM” (proprietary). The approach may utilise 4D programme data and 5D cost elements as well as feed operational systems.
3. Fully open process and data integration enabled by “web services” compliant with the emerging IFC/IFD standards, managed by a collaborative model server. Could be regarded as iBIM or integrated BIM potentially employing concurrent engineering processes.

BIM Industry Working Group (2011) p16 & 17.

None of the surveys reviewed used this model as a measure of the depth of adoption of BIM however it is adopted by this paper as basis of discussion.

2.2 Model Building Practice

The creation of a single integrated BIM model for a project (level 3) does not appear to be current practice. Eastman *et.al.* (2011) provide a useful review of currently available BIM platforms. None of those listed are developed to the point of facilitating a single model. For instance the AutoDesk Revit products have separate packages for Architecture, Structure and Mechanical and Electrical (MEP) which can be compared through another software package Navisworks but remain as separate models. Bentley's core product is Bentley Architecture to which can be added a array of additional systems which Eastman *et.al.* describe as only partially integrated (p82). Archicad is an architecture platform which can be interfaced with third party engineering platforms such as Tekla.

In a case study from Finland (Strenstrand 2010 cited in Firat *et.al.* 2010) there is an instance of the architecture, structural and MEP models being integrated for construction management purposes by importing into Tekla Structures CM module using IFC format. In addition the 2013 Revit suite is claimed to be integrated. Both these instances indicate that some progress is being made towards the evolution of the single model.

The level of detail in current modelling practice is not clearly reported. Eastman *et.al.* (2011) make passing reference to current practice of not undertaking 3D modelling at detail level and reliance on 2D sections for construction details. Similarly Taylor and Bailey (2011) make reference to the practice of modelling the building in 3D to a limited level of detail and then providing construction details (junctions etc) in 2D.

2.3 5D BIM

The issues surrounding cost modelling and management from BIM models have been reported in the literature for some time now. Implicit in the debate are three sub-processes:

1. The extraction of quantities of work to be done from the 3D model and arranging those quantities for estimating purposes.

2. The addition of costing data and the calculation of cost

3. The derivation of costing data from libraries (or databases).

In addition these sub-processes can be applied at any stage of the design evolution from concept design to construction details. For instance RICS documentation suggests that within the RIBA Plan of Work, an order of cost estimate would be made at initial appraisal stage, cost plans at each of concept, design development and technical design stages followed by pre and post tender estimates (RICS 2009).

2.3.1 Derivation of Quantities

Matipa, Kelliher and Keane (2008) based on work they had done in 2006 reported that BIM modelling had huge potential to facilitate designing to a budget but that quantity surveyors encountered serious software interoperability problems that needed to be overcome before the potential could be realised.

Kraus, Watt and Larson (2007) and McCuen (2008) both report that BIM authoring tools are capable of deriving quantities for an object in linear, area or cubic volume form. Hannon (2007) also agreed that quantities could be extracted but noted the difficulty of extracting quantities "to a format that traditional estimators are comfortable with" (p.IT.03.04). Firat *et.al.* (2010) report two case studies in Finland where quantities were taken off from BIM models however in one case they report that "the quantity take off obtained was not considered sufficiently reliable enough for use as the only source of information"(p5). Taylor and Bailey (2011) make reference to the need to manually measure some quantities where construction details are provided in 2D format.

Eastman *et.al.* (2011) describe the existence of third party software tools capable of extracting quantities from various BIM authoring tools which "allows estimators to use a takeoff tool specifically designed for their needs without having to learn all of the features contained within a given BIM tool" (p278). Vico a BIM related software company in a online release (2011) stated "There is no easy button" for quantity takeoff" and made clear that the ability of measurement software to produce a schedule of quantities is limited according to the way the model is built. Taylor and Bailey (2011) observe that for the contractor to develop cost and schedule forecasts from a designers 3D model, they must input reference codes and correct the model where 2D input was used instead of 3D "or make the decision to use 2D printouts and manual methods of estimating and scheduling"(p3). Whitmore 2012 reports in the context of Australia that design consultants have created their own libraries of objects "which results in differing information being extracted from BIM models for similar elements or products"(p19). He offers the opinion that standardising the naming of object properties is the essential next step.

2.3.2 The addition of costing data and the calculation of cost

Eastman *et.al.* (2011) give three primary options for this sub-process:

1. Exporting the quantities to estimating software or an Excel spreadsheet.
2. Linking the quantities of BIM components to estimating software via a plug-in or third party tool. They note that many of the larger estimating software packages provide such tools.
3. Using a BIM quantity takeoff package. Whilst they describe these tools as takeoff packages their detailed description shows them provide costing spreadsheet or database facilities as well as the ability to import manually derived quantities.

The literature reviewed did not discuss this sub-process in any detail and it is assumed to be largely unproblematic as it does not alter pre BIM practice. Whitmore 2012 reports that Rider Levett Bucknell in Australia extract quantities from BIM using a propriety measurement platform (DimensionX by Dimtronics) and then live link the data to their estimating software system "Qubit".

2.3.3 The derivation of costing data from libraries (or databases).

There is discussion on this sub-process in the literature with authors including Kraus *et al.* (2007) Hannon (2007) Eastman *et.al* (2011) and Taylor and Bailey (2011) all seeing this as a desirable goal and a necessary part of effective BIM development.

In 2006 Phair reported that software was available to integrate RSMeans a US costing database with BIM models to enable continual updating of the project costs during conceptual project planning.

However Kraus *et al.* (2007) see the challenge of estimating using BIM is in “how the objects in the building model relate to items in a typical estimating database” (p.IT.01.02). They conclude that for efficient estimating in a BIM environment there is a need to be able to develop and adhere to standards for mapping the objects from the BIM model to the estimating database. They note attempts by various parties in the USA to develop standard protocols for authoring BIM models but go on to observe “that standardisation of how design objects would map to estimating databases is not on the list” (p.IT.01.3). Hannon (2007) also notes the difficulties of mapping design objects to estimating databases.

Bailey (2010) writing in the context of the USA describes preliminary work addressing the problem of mapping design objects to estimating database items. He envisages a future where designers will hold libraries of detailed standard BIM objects identified by codes and contractors will hold cost libraries for the same objects using the same coding system. If this is achieved efficient costing of the project as the design evolved could be realised. He reports progress being made with the use of the “OmniClass” coding system but notes that at this stage “published documentation only provides a level of codes suitable for conceptual and early schematic models and estimates” (p.2). He envisages that the next stage of development will enable some parts of the BIM model to be transferred to the estimating database as “intelligent 3D” with the remainder being addressed using more traditional techniques. More recently Taylor and Bailey (2011) have published an elaboration of this work demonstrating a coding system based on using Omniclass Table 22 at level 2 as its basis with sub-coding providing details on item classification, item configuration and size. The system is not fully developed and again is intended for use during early design stages rather than as a means of deriving quantities for traditional trade based estimating.

The Singapore industry appears to have made the most progress in agreeing a coding system to facilitate exchanges of information between computer based design models and costing systems. The Singapore Standard CP97: Parts 1 & 2 2002 “Code of Practice for Construction electronic standards (CEMS)” is aligned with Singapore Standards CP 93:2002 Classification of construction resources information and CP 83: 2000 Construction computer-aided design, to ensure a common classification and coding system is adopted across the industry.

2.3.4 Extent of 5D modelling in practice.

There is limited reporting of the extent of 5D modelling in practice. The only significant survey found was the RICS BIM Survey Report (BCIS 2011). That survey of members in the UK and USA found that only 10% of respondent QSs said they were regularly using BIM with a further 29% having some limited engagement. Of the responding firms only 6% reported they extracted quantities from a BIM often or very often.

3. New Zealand Practice

3.1 Research Method

The focus of the research for this paper was to identify how 5D practice was evolving at the leading edge of practice rather than provide a survey of the overall extent of practice. However it is accepted that 5D practice is dependent on both the structure of the industry and the modelling being done by design practitioners. An overview of the NZ context is therefore presented first. The extent of BIM usage has been researched by others and this is summarised next. 3D modelling and 5D practice was then investigated and is presented in that order below.

In order to determine current 3D and leading edge 5D practice those considered by industry to be at the leading edge were sort out in a form of purposive non-random sampling as discussed by Denscombe (2007). This was achieved by seeking advice from the Quantity Surveying Advisory group at the authors' institute. This group is comprised of representatives from most large QS firms and Contractors in Auckland. In addition as part of each interview the interviewees were asked who they considered the leading edge practitioners to be. Representatives of one firm of architects, two construction companies, five firms of quantity surveyors and a quantity surveying software supplier were interviewed. Information was also gathered from a member of the Auckland Revit user group, the President of the Pacific Association of Quantity Surveyors and two members of the NZIQS SMM committee. It is believed that this paper therefore provides a reasonable snapshot of the current state of play regarding 5D modelling in New Zealand in early 2012.

The interviews were semi-structured and varied according to the interviewee's role and experience with BIM. Interviews varied between ten minutes (we have no experience of BIM) and one and a half hours.

3.2 The New Zealand Context

New Zealand has a population of approximately 4m people of which about 1.4m people live in Auckland the principal commercial city. The New Zealand construction industry has a similar structure and practices to those found in the UK and Australia rather than those found in North America. A peculiarity of the New Zealand industry which arises in part from the small population size is the lack of large regular clients. The government procures construction related services through individual departments and agencies rather than through a central agency and does not mandate practices in the manner that occurs in other jurisdictions. To date neither the government nor any client group have mandated the use of BIM on its projects, nor become involved in efforts to establish protocols or coding systems.

Most forms of procurement practices can be found in NZ including various forms of integrated project delivery. However the dominant form remains the design – bid – build approach and the industry is structured to deliver in this manner. Design firms are separate entities to construction contractors and none of the larger contractors have in house design capabilities (when design and build type of projects are undertaken the design work is contracted out). Architecture firms tend to be separate from engineering firms and within engineering, civil and structural engineering is often contained within separate firms to mechanical and electrical. It is therefore common to find several design firms (a firm of architects plus two or more engineering firms) on the one project.

Boon (1996, 2001 &2008) described Quantity Surveying is a well established profession in New Zealand. Consultant or Professional Quantity Surveying firms (PQS) exist and are engaged on nearly all projects. Four of the larger firms have ties to and trade under the name of large international firms. Competition law means that neither fees nor levels of service can be standardised, PQS firms therefore provide a variety of services depending on client needs and requirements. Cost planning services can vary between the provision of estimates at the end of each design phase through to detailed cost planning of elements during numerous design iterations. Quantity surveyors are also employed by contractors in commercial management and estimating roles.

3.3 BIM Usage in New Zealand

Davies (2010) reported a survey of computer use and attitudes in the NZ construction industry conducted in 2009, this was based on a postal survey sent to 388 companies from which 80 completed responses (21%) were received. This was a survey of general computer usage not of BIM usage in particular. The survey found that all architect respondents use CAD of some form and that most were using some form of 3D modelling. Six of the architect respondents were using BIM models. Information on the computing practices of other design or quantity surveying firms was not included.

A more recent "National BIM Survey" (Masterspec 2012) was conducted as an online survey in late 2011. It had 524 respondents of which 89% were from Architect, Architectural Designer or Multi-disciplinary firms. It found that of the respondents 34% were aware of and currently using BIM, 54% were just aware of BIM and 12% were neither aware of nor using BIM. 92% of respondents expected to be using BIM in five years time. The survey identified that Autodesk (40%) and Graphisoft (37%) dominated the NZ CAD market.

McCartney and Kiroff (2011) investigated the factors affecting the uptake of BIM in the Auckland architecture, engineering and construction industry using a form of purposive non-random sampling and semi-structured interviews. They found that the interviewees were well aware of the benefits of BIM and did not consider the cost of implementation and training to be major factors restraining uptake. They identified the key barriers to uptake to be the need to do more design and engineering work early, a skill shortage in BIM modelling and the need for a paradigm shift towards a more integrated design and construction process.

3.4 3D Modelling Practices

The information in this section was collected from interviews with the organiser of the Auckland Revit user group, from the BIM managers of two major construction companies involved in tendering for larger projects and from the QS firms interviewed. The first interviewee provided insight into the practices the design professions share through the user group whilst the other two groups provided coverage of a significant proportion of non-residential projects in the Auckland market over the previous year. All the people interviewed were involved with projects where the contractor had been brought into the project after a tender process at the end of the design phase (including the production of construction documentation).

3D modelling using BIM authoring tools is commonly found on larger projects. Its use on small and medium projects is less common. Two quantity surveying firms who work on small to medium projects reported that they had yet to see a project modelled in 3D. Where 3D modelling is used it is rare to find that all design consultants have modelled in 3D. Instances were found where the architect had drawn in 2D and the structural and services engineers had modelled in 3D and where the architect and structural engineers had used 3D and the services engineers 2D. The interviewees were generally of the opinion that the structural engineering profession was the most advanced in the use of BIM and the services engineers the least advanced. The use of BIM by services engineers appeared to vary between using it simply as a drafting tool through to using its full performance modelling capabilities. In all cases where BIM was used separate architecture, structure and services models were produced. This is inevitable as the commercially available BIM authoring tools do not facilitate the production of a single integrated model (see 2.2 above).

Most architecture firms that were modelling in 3D were only taking their models to a level of detail equivalent to 1:100. Construction detailing to a greater level than this was being done in 2D. The architectural firm interviewed reported that whilst they sometimes did the preliminary design using a BIM authoring tool they started a new model at the commencement of developed design and did not flow through the model from preliminary design. Some architects within the firm did the preliminary design using Google's SketchUp before moving to a BIM authoring tool at the commencement of developed design.

In all instances covered by the interviews the contract documents were 2D drawings not the 3D model. Where a 3D model was provided to the contractor it was on the basis of "information only".

The industry has not established modelling protocols, these are therefore negotiated on a project by project basis. Tensions exist between how the design consultants can efficiently produce models that meet their purposes and the additional level of detail that can be required to enable location based scheduling and estimating information to be developed. Whether columns and lift shafts should be modelled as a single object which extends the full height of the building or be modelled on a floor by floor basis is a typical example of this tension. Coding or description protocols for objects in the models have not been agreed. Each organisation therefore has its own practices which are not always followed consistently.

The state of BIM practice where it exists can therefore be characterised as being between level 1 and early level 2.

3.5 5D Practices

3.5.1 Software Capability

Boon, Prigg and Mohammad (2011) looked at the issues of cost modelling through the design phases of the project in the NZ environment. They conducting experiments of practice in an academic environment based on advice from industry practitioners. The 5D modelling was not carried out using the capabilities embedded in the proprietary BIM authoring tool used to create the 3D models, instead third party proprietary estimating software (5D) was used. The data in the base BIM model was converted into DWF or DWFx files and exported to 5D software. The 5D software was used to derive the quantity data required for cost modelling, then to connect the quantity data to costing data using relational databases that form part of the 5D package.

The cost modelling practices undertaken in these experiments mimicked the breakdown of the design process into the following phases:

1. Early stage estimating using techniques such as a rate per m^2 of gross floor area (GFA).
2. Elemental cost estimating during the design process, based on a cost per unit of element (or sub-element) such as m^2 of internal walls measured in accordance with rules of measurement such as the New Zealand Institute of Quantity Surveyors' (NZIQS) Elemental Analysis of Cost of Building Works (1992) or the RICS new rules of measurement Order of Cost Estimating and Elemental Cost Planning (2009)
3. Estimating based on measurements derived from a construction ready model in accordance with a standard method of measurement such as NZS4204 (1995) or the UK SMM7.

They concluded that:

> Automation of elemental and sub-elemental estimating within a BIM environment is already substantially possible as there is a close alignment between BIM objects and sub- elements. To achieve automation of pricing by reference to a standard rate library it is necessary to develop a coding system and use it consistently. It is believed that this is possible within the current context of development of BIM (p31).

However they found greater difficulty with preparing quantities derived from a construction ready model in accordance with a standard method of measurement such as NZS4204 (1995) or the UK SMM7 due to the composite nature of objects within the model. The objects typically contain more than one trade, for instance an internal wall may include framing, dry lining, finishing and decorating trades.

3.5.2 Current Consultant Quantity Surveyor Practice

The information in this section is taken from interviews with three of the largest PQS firms in Auckland. They were selected on the advice of the QS Advisory group as described above as being consultants engaged on projects where at least some of the design consultants were using BIM authoring tools. Other firms were also suggested but they disqualified themselves in initial telephone approaches as not having worked on projects where they were aware of BIM authoring tools being used. The practices described below are therefore believed to represent leading edge practice in NZ as at early 2012.

3.5.2.1 Derivation of quantities

Two of the three firms did not extract quantities from 3D models, preferring to work in 2D format. They used estimating software tools to measure on screen from soft copies of 2D drawings. At times they also measured from hard copy. Neither of these firms had attempted to move to 3D format, those interviewed believed the firms' employees would be reluctant to retrain to use new software (younger employees being the exception to this).

The third firm had experience of extracting quantities from 3D models. Their experience was similar to that found by Boon, Prigg and Mohammad (2011) described above; extraction of quantities for preliminary and developed design phase estimating being relatively simple. The interviewee did however emphasise the importance of the QS being able to identify items that were not in the model at the time of quantity extraction.

When measuring for the purposes of preparing trade based schedules of quantities they also found greater difficulty. As described above where architects were using 3D models it was only to a level of detail equivalent to 1:100 drawings, the amount of information that could be extracted using the measurement software was therefore limited by the lack of detailed information in the model. Basic horizontal and vertical lengths and areas could be derived and taken into the scheduling software for descriptions to be added manually. This was seen as being of only marginal benefit over measuring from 2D softcopies of drawings although vertical dimensions were easier to obtain. Enumerated items such as doors and windows could be more easily derived automatically as they are separate objects within the model and typically had sufficient descriptive information for them to be scheduled with only minor editing. Some items such as timber framing in walls are not modelled and no benefit is gained over measuring from 2D drawings.

Where a well developed structural model was available considerable efficiency could be gained in the scheduling process. Concrete and reinforcing steel volumes could be easily derived but not formwork quantities as this is not modelled. In the case of precast concrete flooring planks it was found that more detailed schedules than had traditionally been provided could easily be derived from the models. These took the form of enumerated schedules listing each precast concrete plank by type length and location. Structural steel quantities could be derived in almost any desired form typically either by weight or by type of member and length. Scheduling by enumerating each steel part was also possible. The steel in fixing cleats etc could not be derived from the model as it was not detailed, it either had to be measured manually from 2D details or a weight allowance made. The interviewee reported an occasion where they had firstly derived the quantities for a complex roof truss using the measuring software and then manually checked the quantities. A small difference was found, the software showing some additional members that the experienced surveyor doing the manual measure could not find on the drawings, despite the drawings he was using being derived from the 3D model. Using the software these were traced down to a location that could be shown by rotating the 3D model but which was not visible on 2D drawings.

In the case of services the ease of scheduling was very dependant on the level of detail in the model. On one project the mechanical services engineer had developed a fully detailed model including embedding full specification details into the drop down boxes associated with each object. In this case scheduling was reported as being “amazingly easy”.

Whether quantities could be easily scheduled by location (e.g. separate quantities for each floor or zone) depended on how the 3D model had been constructed and the nature of location information desired. If vertical members such as columns and lift shafts had been drawn in the model as single objects running up the full height of the building the floor by floor quantities could obviously not be automatically derived. However if the desired location information was by blocks or horizontally divided zones these could be derived more easily.

3.5.2.2 The addition of costing data and the calculation of cost

Two of the firms used a third party estimating software package; the third used their own proprietary system. These estimating packages comprise a measurement “engine” and relational data bases within which quantities and costing rates are drawn together to produce an estimate. The difference between 3D and 2D versions of the package was only in the measuring engine the relational data bases are the same. These relational databases facilitate three ways of deriving the rate. Firstly by direct entry, secondly by building up the rate on a project specific basis in interconnected spreadsheets and thirdly by connecting to a central rate library.

When doing elemental estimating during the developed design phase none of the firms used the UK method of analysing the priced schedule of quantities of previous projects to determine element rates. Their practice is to build up rates for elements using approximate quantities and rates from schedules of quantities of similar projects. Because of this they do not maintain a centralised data base of element rates but do build up project based databases. An equivalent of the UK BCIS service does not exist in NZ.

The firms often price the schedule of quantities at the same time that contractors are preparing their bids. Typically they derive the prices used from a combination of reference to prices in SoQs on previous projects and by seeking advice on current prices from sub-contractors and suppliers. They do not maintain central libraries of unit prices for this purpose.

3.5.2.3 The derivation of costing data from libraries (or databases)

As described above it is not the current approach of these firms to maintain central rate libraries, neither does a national service equivalent to the UK BCIS exist. The ability to link with a central library had therefore not been tested by the interviewees. They did however all note that the absence of agreed coding or descriptions systems would be need to be overcome before this was possible.

Those interviewed were ambivalent as to the advantages of such libraries. The common opinion being that to automatically link project specific quantities to a central rate library was risky and that it was important to build up rates for each project during which professional judgment was exercised around costing variables such as project location and complexity as well as changing market conditions.

4. Development of a Coding System

The information in this section is derived from interviews with the facilitator of the Auckland Revit user group, the President of the Pacific Association of Quantity Surveyors and two members of the NZIQS SMM committee.

As noted above protocols for coding objects within BIM models have not yet been agreed in NZ. Some design firms have developed their own systems but in some cases regard this as their own intellectual property and do not wish to share it. Where systems are being developed they generally use a coding system based on the New Zealand Coordinated Building Information (CBI) classification and coding system established by ACBINZ (the Association of Coordinated Building Information in New Zealand). This is similar to the OmniClass system advocated by Bailey (2010) as described above. The use of this coding system is favoured in part as it is also used as the structure for "MasterSpec" a commercial specification system that is widely used by architectural firms.

The NZIQS have a sub-committee which is reviewing the NZ standard method of measurement (NZSMM). That group have concluded they should also adopt the CBI system. As the coding system adopted is similar to that used in the Singapore CEMS it is anticipated that the structure of the revised NZSMM will therefore also be similar. This alignment between the standards is likely to be further encouraged by global discussions currently underway between quantity surveyor groups including the RICS and the Pacific Association of Quantity Surveyors which it is understood is looking at developing an international SMM similar to the CEMS as a global standard.

It is likely therefore that at some stage in the future in NZ we will see some convergence in coding practice around the CBI standard. At that point we may also see the emergence of the use of formal rate libraries by QS firms but this currently looks to be some way off.

5. Conclusion

In New Zealand where BIM is being deployed on larger projects it is at level 1 or 2 as defined within the Bews and Richards (2008) model. At this level it possible for cost modelling to take place without PQS practices changing their existing procedures. Firms who do this do so by working from 2D drawings extracted from the 3D model and not the model itself. The primary difference between cost modelling in a BIM environment and quantity surveying practice in a non-BIM environment is in the ability to use software to extract quantities of objects with their appended properties direct from the BIM 3D model. Once the quantities are extracted they can be manipulated within relational data bases or spreadsheets in much the same manner as in a non-BIM environment. Within the BIM environment further potential exists to match object descriptions within the 3D model with libraries containing costing rates for the same objects thereby making the estimating process more efficient, however this process requires prior agreement of coding and description systems. Such agreement has not yet happened in NZ and appears to be only at the early stages of development internationally. This potential benefit could be gained using existing estimating software, the barrier is firstly with agreeing coding and description systems and secondly with NZ practices establishing formal rate libraries.

Within the NZ environment the ability to extract quantities directly from the BIM model exists but its use on large projects currently appears to be limited to one PQS firm. The extraction of quantities in this manner for estimating during the design phase does not appear to present significant problems and seems to be held back by a reluctance to adopt new practices. Extraction of quantities for incorporation into trade based schedules of quantities presents greater difficulties as the objects in the model do not always align with the trade based nature of the work to be done. However given that the firms interviewed already had the skills to measure from 2D soft copies of drawings the change to measuring from 3D models does not seem great and would provide some gains in efficiency.

Cost modelling in a BIM (5D) environment as currently practiced in NZ takes place outside of the core BIM model using 3rd party estimating software and not within the core BIM authoring software. This appears to be similar to international practice. The idea of costing data being embedded in the core BIM as part of the "data rich" environment that might be envisaged with level 3 BIM does not yet appear to be on the NZ industry's agenda.

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Economic justification of non-commercial buildings renovation or substitutional construction

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Abstract

Global crisis in economy has forced the owners of buildings into negligence of old buildings. Therefore we have many buildings which are crumbling. This may also happen to new buildings, as the owners too many times do not work responsible or economical. Lack of owners' knowledge how to work with buildings, how to maintain them regularly and when to rehabilitate them, is many times the reason of new and old buildings' negligence. Unfortunately the owners are not aware of the fact that outlook of building reflects owners' relationship to maintenance and rehabilitation of the buildings. There have existed many neglected buildings all over the world already before the global crisis which are neglected because of many reasons. This raises the question until when is it economically justified to maintain older buildings and the construction of new building is not worth of money. The aim of the research is to find an optimal multicriteria decisive model of economic justification of non-commercial buildings renovation or substitutional building. The value of buildings decreases due to lack of maintenance; therefore certain buildings are less worth if they are not maintained and renovated. At existing buildings are present many factors which are reducing the value of buildings or real estate. In practice we know three types of deterioration or obsolescence of buildings or real estate, which reduce the value of buildings. In the model these are treated as criteria: physical deterioration, functional obsolescence, and economic obsolescence. The model considers buildings which service for public purpose and are not protected as cultural heritage. We have developed theoretical multicriteria decisive model of economic justification of non-commercial buildings renovation or substitutional construction. Thus it will be possible for owners of non-commercial buildings to decide regarding to criteria of physical deterioration, functional and economic obsolescence about renovation or substitutional construction if any of these are identified as economic justified.

Keywords: non-commercial building, physical deterioration, functional obsolescence, economic obsolescence, renovation, substitutional construction.

1. Introduction

Non-commercial buildings in the public ownership are not maintained and renovated as they should be because of general saving in public sector. Thus older buildings begin to diladaptate and the costs of renovation in the future consequently increase. This is also going to happen to newer non-commercial buildings as the owners do not act responsible or economically. The reason of diladaptation of old and new non-commercial buildings is also owners' lack of knowledge, they do not know how to work with buildings, how to maintain them regularly and when to rehabilitate them. This raises the question until when is it economically justified to maintain and renovate older non-commercial buildings.

Non-commercial buildings, also called buildings of social standards or public buildings, are buildings which are built for non-commercial activities. Among these are buildings for activities of public administration and defence, activities of compulsory social security, education, health care, social assistance, cultural activities, entertainment and recreation. (Pšunder M., Klanšek U., Šuman N., 2009).

Many factors reduce the value of buildings or real estate at existing non-commercial buildings. In practice we know three types of deterioration or obsolescence of buildings or real estate, which reduce the value of buildings. In the model these are treated as criteria:

1. Physical deterioration: the reduction of buildings' value, caused for the reason of the consequence of use and deterioration of condition.

2. Functional obsolescence: the reduction of buildings' value, caused for the reason of bad construction, structure or material, which cause reduced usefulness of real estate.

3. Economic obsolescence: the reduction of building's value caused by influences resulting from environment. These can be changes in standardisation, legislation, infrastructure or urban design of environment.

We do not consider the criteria of profit in deciding whether to renovate non-commercial building or to demolish it as we do at economic buildings. There exists public benefit which brings some profit but not directly. At renovation of that kind of buildings it is only public interest to renovate or build substitutional building with economic use of public sources. For that reason we do not consider the profit.

We have developed multicriteria decisive model in order to estimate economic justification of renovation or substitutional construction of non-commercial buildings. It is the definition of time limit in the buildings' lifetime until when is it economic justified to renovate or rehabilitate. Thus it will be possible for owners of non-commercial buildings to decide regarding to criteria of physical deterioration, functional and economic obsolescence about renovation or substitutional construction if any of these are identified as economic justified. The model does not consider buildings which are subjects of cultural heritage as they are specific and have to be renovated in accordance with requestments and guidance of institutes for heritage protection.

2. Theoretical Basis

There are not any multicriteria decisive models of economic justification of renovation or substitutional construction of non-commercial buildings developed in scientific data bases. Vanier et al (2006) have developed decisive model for management of buildings' funds.

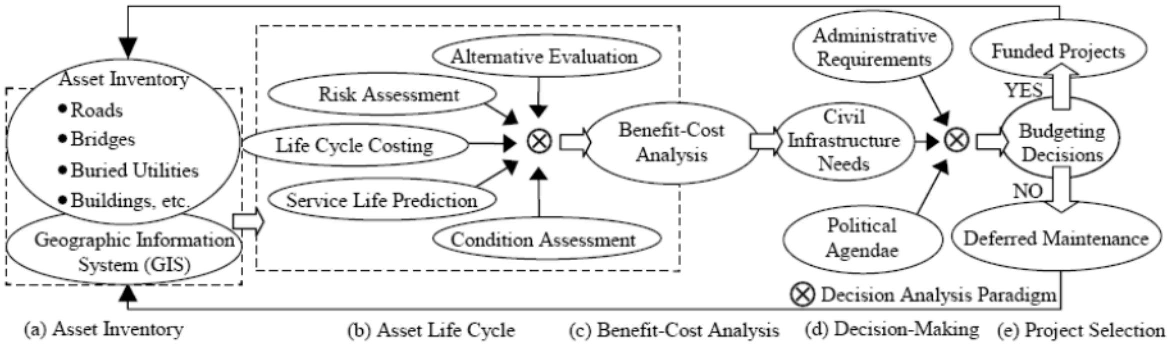

Figure 1: Proposed framework for making decision (Vanier and Lounis 2006)

Figure 1 represents the framework of decisive model for management of buildings' funds. It is the model devoted to specify the building which most needs certain works. Model is based on the proportion of funds invested and benefits which can be defined thought costs and benefit's analysis. The model uses the structure of analytic hierarchy process (AHP) which is multi-criteria decisive ethnic used for creating measurements. AHP method uses objective mathematics for the procedure of subjective and personal preferences of individual or groups at making decisions. AHP method works on premise that complex problems can be treated with their structuring in simple and understandable structure. (Vanier and Lounis 2006).

During the process of multicriteria deciding we have to develop a model for selected decisive problem, which will ensure objective valuation of variants according to the aims of the problem. There are many methods to support multicriteria deciding. Some of them are appropriate for simple decisive problems with small number of criteria; the others are provided to the most difficult problems and are also more complex. (Bohanec, 2006).

3. Multicriteria model of renovation or substitutional construction of non-commercial buildings

At selected multicriteria decisive model of economic justification of renovation or substitutional construction of non-commercial buildings only one building is treated. Model is based on the fact that renovation has priority over renewal which is also the aim of sustainable development worldwide. Figure 2 represents the whole procedure of multicriteria deciding about renovation or substitutional construction of selected non-commercial building.

Firstly we prepare document of investment project identification for decision about renovation or substitutional construction. This document involves analysis of the investor's situation and justified reasons for need for implementation of investment intention, investments aims and cost estimate. After implementation of this document we have to prepare pre-investment concept of renovation variant of existing building or substitutional building variant. This is small-scale elaborate, by which investor wants to justify planned construction. He proves in elaborate the need of construction and that he has all necessary financial sources which are planned to be spent for construction and that investment is economic justified. Pre-investment concept is very interdisciplinary, thus it requests cooperation of many professionals. Thus approach to make this concept has to be team approach. Next step is to prepare investment program which is almost the same, however more detailed handled. Investment program includes only one variant of existing building renovation and one substitutional building variant. On the basis of this ideal project has to be made for each variant of existing building and substitutional building. In respect of these elaborates we get all necessary data for further judgement by multicriteria decisive model.

After preparation of document of investment project identification, pre-investment concept and investment program we have to make group of 3-5 professionals from the scope of civil engineering and real estate estimation who will estimate by multicriteria model which decision is better for investor.

Criteria of multicriteria deciding have been defined on the basis of equation which has been developed on the basis of determination of building's value after certain time. Building loses value because of physical deterioration, functional and economic obsolescence. Thus we have mathematically formulated the value of building or fixed property after the certain time as (Kovačec, Pšunder, Soršak, 2010):

$$V(t) = Vi - dPHY - dFUN - dE \tag{1}$$

Where is:

V(t) – value of real estate after the certain time;

Vi – initial value of real estate;

dPHY – extent of physical deterioration for which the value of real estate is reduced;

dFUN – extent of functional obsolescence for which the value of real estate is reduced;

dE – extend of economic obsolescence for which the value of real estate is reduced.

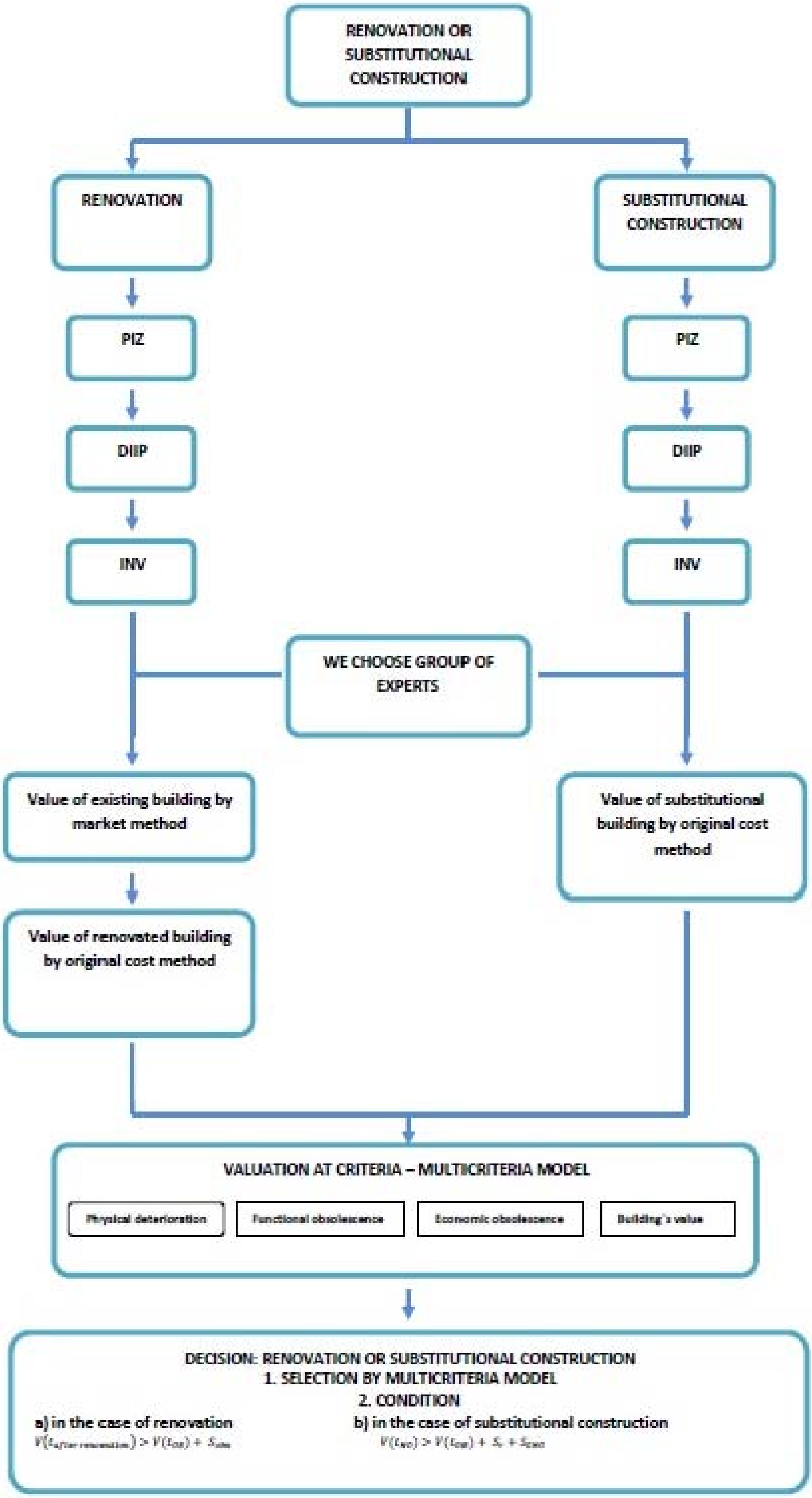

Figure 2: Multicriteria decisive model of renovation or substitutional construction for non-commercial building

Multicriteria deciding is made after Table1, where all criteria and sub criteria are indicated. The group of professionals firstly defines and expresses those criteria. When they conclude defining criteria and sub criteria, they begin to estimate benefits of criteria and sub criteria for all variants of renovation and substitutional construction and define weighting individually.

Table 1: Multicriteria deciding

CRITERIA		***Renovation of the building – Variant 1***			**. . .**	***Substitutional building – Variant x***		
Main criteria (k)	***Sub-criteria (k_p)***	***Sub-criteria weighting (u_{p1})***	***Criteria weighting (u_{k1})***	***Benefit (b_1)***		***Sub-criteria weighting (u_{px})***	***Criteria weighting (u_{kx})***	***Benefit (b_x)***
PHYSICAL DETERIORATION (a_1)	*Quality of the building (y_1)*							
	Remaining life time (y_2)							
FUNCTIONAL OBSLOLESCENCE (a_2)	*Construction's condition (y_3)*							
	Condition of built materials (y_4)							
	Cost of maintenance (y_5)							
	Energetic efficiency (y_6)							
	Cost of heating (y_7)							
ECONOMICAL OBSOLESCENCE (a_3)	*Location (y_8)*							
BUILDING'S VALUE (a_4)	*Value of the building (y_9)*							
VALUE								

After determination of criteria and sub criteria weighting and after determination of unity of benefits we start with calculation of benefit for each individual variant, thus renovation and substitutional construction, after following equations:

$$b_{1a1} = (u_{p1(y1)} * b_{1(y1)} + u_{p1(y2)} * b_{1(y2)})/100 \tag{2}$$

$$b_{1a2} = (u_{p1(y3)} * b_{1(y3)} + u_{p1(y4)} * b_{1(y4)} + u_{p1(y5)} * b_{1(y5)} + u_{p1(y6)} * b_{1(y6)} + u_{p1(y7)} * b_{1(y7)})/100 \tag{3}$$

$$b_{1a3} = (u_{p1(y8)} * b_{1(y8)})/100 \tag{4}$$

$$b_{1a4} = (u_{p1(y9)} * b_{1(y9)})/100) \tag{5}$$

After that we calculate the final benefit for variant of renovation after the following equation:

$$b_1 = (u_{k1a1} * b_{1a1} + u_{k1a2} * b_{1a2} + u_{k1a3} * b_{1a3} + u_{k1a4} * b_{1a4})/100 \tag{6}$$

In general we write down the calculation of benefit for individual variant as:

$$b_{xa1} = (u_{px(y1)} * b_{x(y1)} + u_{px(y2)} * b_{x(y2)})/100) \tag{7}$$

$$b_{xa2} = (u_{px(y3)} * b_{x(y3)} + u_{px(y4)} * b_{x(y4)} + u_{px(y5)} * b_{x(y5)} + u_{px(y6)} * b_{x(y6)} + u_{px(y7)} * b_{x(y7)})/100 \tag{8}$$

$$b_{xa3} = (u_{px(y8)} * b_{x(y8)})/100) \tag{9}$$

$$b_{xa4} = (u_{px(y9)} * b_{x(y9)})/100) \tag{10}$$

$$b_x = (u_{kxa1} * b_{xa1} + u_{kxa2} * b_{xa2} + u_{kxa3} * b_{xa3} + u_{kxa4} * b_{xa4})/100 \tag{11}$$

When we get final benefit for the example of renovation of existing building and substitutional construction we compare both benefits and choose the one with the higher value. Thus we get the decision through multicriteria model whether to renovate the building or to construct substitutional building. If we get the result to renovate the building again we check the equation from Figure 2 under renovation. If we have an example to construct a substitutional building, we check the equation from Figure 2 under substitutional building. In the case that proposed decision does not comply with conditions from equations on Figure 2, we check investment program and study the whole investment of selected solution again. In the case that we get negative result, the appropriate solution is the opposite of proposed, which should be checked according to equations.

4. Conclusion

It is possible by the use of multicriteria decisive model to determine in which time period of building's lifetime is it wisely and economic justified to make decision not to maintain and rehabilitate the building anymore but to demolish it and build the new or substitutional building according to criteria, namely physical deterioration, functional and economic obsolescence in conjunction with building's value.

According to intensity of construction in the past years we can expect more obsolete buildings and real estate for which decisions about renovations or substitutional construction will have to be made in the right moment. Considering the criteria of obsolescence and deterioration in connection with building's value and profit or benefit and the new model it will be possible to improve quality of decisions of renovations or demolitions of obsolete non-commercial buildings.

This model will be further developed in the way to determine final input parameters and verify multicriteria decisive model on practical cases at non-commercial buildings.

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Early stage evaluation of the socio-economic benefits of built environment regeneration (SEBER) projects

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Abstract

In recent years, sustainable regeneration has been recognised as being of major economic and social concern in the world. These two concerns, often referred to as the double-bottom line are seen as the main ingredients of sustainable regeneration programmes. In the UK for instance, government has initiated a number of policies and evaluation methods in dealing with some of the environmental problems associated with regeneration programmes. But the approach to these programmes and projects management has often been seen and described as not achieving their set objectives. Attempts aimed at implementing sustainability have primarily been limited to the assessment of potential environmental benefits, with the economic and social aspects often neglected. However, the pursuit of sustainable regeneration requires a fundamental change and a more holistic approach to early stage project evaluation and management of regeneration processes to deliver the required benefits the projects are designed to achieve. While there have been numerous studies on sustainability evaluation of regeneration projects in the UK, there has not been any well-defined research that has been able to deal holistically with the broader targets of sustainability performance and benefits to the end-users and their communities. The findings of an exploratory study that interviewed seven senior managers and directors of leading construction industry organizations involved in the regeneration projects in the UK are presented in this paper. The findings reveal a lack of an early stage evaluation framework and mechanism for evaluating the socio-economic factors of sustainability of regeneration projects at the early stage of their evaluation process. The results suggest that the environmental factors of sustainability continue to be the most dominant factor of sustainability as compared to the economic and social benefits. This paper is drawn from on-going research in the general area of socio-economic benefit evaluation of sustainable built environment regeneration (SEBER) projects. The study therefore concludes by identifying the need to develop a comprehensive range of indicators that can be used for early stage evaluation of the socio-economic benefits of potential regeneration projects.

Keywords: Social and economic benefit, early stage evaluation, sustainable regeneration.

1. Introduction

The concept of sustainable development and regeneration has been an essential focal point of government policy for sometime in the UK and has contributed to the enhancement of many communities' physical structures (Haran *et al*, 2011). Many of the earlier initiatives that were meant to tackle socio-economic disparities have focused on improving the physical and environmental aspects of regeneration. In more recent times, there have been a number of researches which sought to study and analyze how the UK built environment is responding to the challenges of integrating sustainability into regeneration projects (Dixon, 2006). These emerging researches and initiatives have sought to suggest a new approach to delivering regeneration for the 21st century and beyond. The Sustainable Development Commission, (SDC, 2003), suggested that the development of regeneration has proved to be a testing and on-going challenge for government agencies, construction industry practitioners and communities within the UK. The appreciation of such challenges has led to the development of various management strategies and systems to guide and direct industry practitioners and activities to achieve higher and improved sustainability standards. However, attempts aimed at implementing sustainability assessment have primarily been limited to the assessment of the environmental performance of building. According to Brandon and Lombardi (2011), previous works undertaken on sustainable regeneration have shown that they lack a conceptual clarity related to sustainability assessment. They identified sustainable regeneration/development as an evolving field and suggested the need for further study as there has not been a well-defined evaluation framework that has been able to deal with the issues of socio-economic benefit/impact and their evaluation in a comprehensive and a decisive manner. It is quite clear that the present project management systems, the industry structure, the policy and governance structures, and the nature of the assessment systems all have influence on the current construction industry practices' related to regeneration programmes. Consequently, the quest for sustainable regeneration impact evaluation calls for an exploration of new ways of evaluating sustainable regeneration projects that are under-pinned by strong socio-economic considerations; and which better address sustainability concerns in a holistic manner to maximise the sustainability benefits of these projects.

This paper explores the early stage evaluation of socio-economic benefits of sustainable regeneration projects in the UK. The first part reviews literature on sustainable development and regeneration, the evaluation processes and mechanisms, the socio-economic framework and their policy objectives. The final part of the paper presents the discussion and the findings from semi structured interviews with leading construction industry organizations involved in regeneration projects in the UK, and conclusion. This paper is drawn from on-going research concerned with the development of a framework for social and economic benefit evaluation of regeneration (SEBER) projects in the built environment.

2. LITERATURE REVIEW

2.1 Sustainable regeneration a driving force for sustainable development

The transformation of the urban and built environments is often viewed largely in physical terms, for instance, the construction of new a hospital, school, housing etc in a community (Boyko *et al*., 2006). Roberts (2000, pg 17) defines regeneration as a *"comprehensive and integrated vision and action which leads to the resolution of urban problems and which seeks to bring about a lasting improvement in the economic, physical, social and environmental condition of an area that has been subject to change"*. Fundamentally, regeneration is about closing gaps (Community and Local Government (CLG), 2010) and tackling the spatial disparities of communities (HM Treasury, 2007). Regeneration means different things to different people. The ultimate objective of the regeneration concept is to transform an area economically and socially by creating sustainable places where people want to live, work and feel secure (CLG, 2009). Sustainable regeneration means meeting the needs of the people in a way which delivers social progress, economic growth, environmental protection, and better quality of life (Office of Government Commerce (OGC), 2007; SDC, 2003). A sustainable regeneration process should be based on a strategic plan that sets out a comprehensive framework so as to ensure that outcomes such as; wealth creation, well-being, sustainable jobs and lasting legacy for the communities are delivered. The necessary infrastructure development required to meet the needs of the growing world population poses a major challenge (UN-Habitat, 2009). Consequently, sustainable regeneration projects have the potential to contribute to socio-economic structures in the communities in which they are sited if they are well planned and managed.

The Office of Deputy Prime Minister report (ODPM, 2005) identified five key elements of sustainable regeneration in relation to planning and management of communities as; sustainable economic growth; social cohesion and inclusion; protection and enhancement of the natural environment; prudent use of natural resources; and the integration of sustainability into development plans. In its most recent iteration, five key elements of sustainability were identified in relation to the integration of sustainable development in urban development plans. Sustainable urban regeneration projects should take into consideration the interaction between physical, social, environmental and economic concerns (Yau and Chan, 2008). A successful sustainable regeneration programme/project will reinforce a better socio-economic condition and enhance the quality of lives, particularly for people living in deprived localities (CLG, 2008). According to Smith (2006) regeneration programmes should not only address physical and environmental features, but also consider the broader issues of economic and social factors as well. As such, any regeneration programme that fails to evaluate each of the well established sustainability pillars is not likely to achieve its sustainable development objectives (Winston 2009). Sustainable regeneration projects have the potential to reinforce a sense of community confidence, make an important contribution to the local economy and act as a catalyst for improving the wider area (ODPM), 2005). Accordingly, the relationship between the built environment and sustainable development shows greater potential for the implementation of sustainable regeneration initiatives with wider and stronger emphasis on the socio-economic development and better quality of life for all. It has been acknowledged that a successful regeneration programme which is centered on the social and economic well-being of the people concerned is more likely to deliver tangible and sustainable benefits (Haran *et al*, 2011; CLG, 2008). Of course this will require the development of evaluation systems and policy frameworks that embrace other dimensions beyond the current consideration of sustainability and not one that is only environmentally oriented (Dixon, 2006; SDC, 2003).

2.2 Evaluation drivers of sustainable regeneration

There is an emerging recognition that the improvement of the socio-economic structures in a community is more likely to deliver sustainable outcomes of regeneration projects (Adamson, 2010; SDC, 2003). The built environment influences social welfare and human well-being, urban activities, the economy and the general environment in numerous ways. According to Sev (2009) the linkages between sustainable development/regeneration and the built environment has become evident, since construction is of high socio-economic significance. Therefore, the application of evaluation mechanisms requires a level of consideration beyond the current focus on environmental performance by the available methods such as the BREEAM, etc to include socio-economic considerations of regeneration projects. Such evaluation practices must be carried out in a way that is comprehensive, practical and acceptable to a range of projects and stakeholders with differing interests and priorities to achieve the required benefits. According to the United Nations (UN, 2001), evaluation processes provide crucial guidance for decision-making in a variety of ways. Thus, they offer early warning on economic, social and environmental damage, communicate ideas and values. Brandon and Lombardi (2011) asserted that unless some evaluation can take place it will be difficult to ascertain whether sustainability is achieving its desired objectives. While a number of evaluation tools and frameworks have been developed over the years, there seems to be no consensus and agreement in the selection of indicators among various bodies responsible for the evaluation of sustainability (Brandon and Lombardi, 2011). They made a call for a new approach and assessment framework which is able to make value-based judgements in a consistent manner so as to explain the complexity underlying decisions for sustainable development.

2.3 Overview of project evaluation mechanisms

There has been a number of project related evaluation methods developed in the past notable among them are the conventional initial parametric and construction cost models (Fortune and Cox, 2005). Recently, there has been a significant growth in the number of environmental and sustainability assessment methods available for use in the construction industry such as the BREEAM, fuzzy logic, neurofuzzy systems and other environmental and sustainability life cycle cost models (Mateus and Bragança, 2011; Fortune and Cox, 2005). A plethora of evaluation systems and tools have been developed for the purposes of appraising the environmental and sustainability performance of building projects, in areas such as the use of energy in buildings, indoor environment and building materials containing hazardous substances (Forsberg and Von Malmborg, 2004). While some of these system and tools have focused mainly on evaluating the environmental and sustainability performance of the proposed developments, others have placed emphasis on the assessment of their environmental and sustainability impacts (Ding, 2008). The development of various forms of evaluation methods has largely been informed by the desire to provide building projects with a better profile of environmental performance and the achievement of the best practice in sustainable building design, construction and operation. Cole (2006, pg. 368) argued that the subject of sustainability and building performance assessment methods are constantly developing, therefore “the time and effort required to keep pace with several systems are clearly of importance”. In order to ensure the achievement of value for money in sustainable regeneration projects, it is essential that project delivery is under-pinned by strong project related socio-economic evaluation. Such an approach would in turn generate data that would be vital in providing lessons for future interventions to ensure more efficient future regeneration development.

2.4 Limitations of evaluation methods

Although the range of evaluation methods indicated above have been developed and applied in the construction industry over the period, their focus and attention has remained limited to evaluating the environmental impacts of a proposed building at its design stage (Hurley and Horne, 2006). Such evaluation objectives and procedures have traditionally been limited to design cost and environmental factors, and their validity and reliability for evaluating socio-economic sustainability factors at both pre-project and post project stages still remain to be tested. The role and usefulness of conventional project evaluation methods have also been put into question (Heijungs *et al*., 2010). It has also been suggested that many evaluation methods have been utilised as design tools or devices and centred mainly on evaluating environmental improvements of building designs (Haapio and Viitaniemi, 2008; Cole, 2005). Brandon and Lombardi, (2011) pointed out that the current list of available methods do not reflect the complexities of issues they were designed to address. They noted that most of the existing evaluation methods were based on environmental criteria that were derived from ideas and assumptions of individual practitioners. Ding (2008) and Cole (2005) identified data intensiveness, impracticality and late application as some of the major criticisms that have been labelled against them. They went on to suggest that a number of the current evaluation methods were still functioning as voluntary and market place mechanisms and this was undermining their importance and usefulness. As such, over generalization and reliance on environmental factors were also recognized by the industry practitioners as some of the weaknesses inherent in the current systems which have hampered their usefulness and day-to-day application (Jeswani *et al*, 2010; Ding, 2008).

2.5 The emerging issues

However, the pursuit of sustainable regeneration and sustainable building development requires a fundamental change of perspective to the evaluation practices currently in use. Accordingly, an effective evaluation method requires a level of consideration beyond the current focus on environmental performance to include the socio-economic considerations of sustainable regeneration projects. However, Brandon and Lombardi, (2011) indicated that the current thinking needs to be considered alongside the improvement or replacement of the conventional methods with those that better addressed sustainability concerns holistically to enhance their evaluation performance. Since buildings and their components undergo continuous transformations and deterioration over their lifetime, it therefore suggests that any system meant to evaluate them must also be designed in such a way that makes them adaptable and responsive to these changes. Therefore, in order for evaluation methods to be useful so as to meet projects' sustainability requirements, there is the need to develop comprehensive frameworks which seek to adopt a holistic approach by integrating the principles of sustainability into the building processes Ding (2008). Such an approach would set out standards and consider innovative solutions that maximize the sustainability benefits of potential projects. This phenomenon will certainly lead to the attainment of sustainability objectives considered as an integral part of a building project's delivery process. This will require a comprehensive policy framework and a broad-based approach from all the stakeholders within the built environment; and the application of multiple methods of early stage project evaluation as opposed to the single methods based on conventional capital cost forecasts which are explicitly inherent in the approaches currently in-use as reported by Ding (2008).

2.6 Socio-economic framework and policy objectives

There is no doubt that sustainability considerations are inherently multifaceted and multidisciplinary, as a result there are several issues that need to be addressed to develop a practical set of sustainability criteria to achieve the harmonisation of sustainability objectives (Ugwu and Haupt, 2007). Van Bueren and De Jong (2007) maintained that, most policy documents on sustainability exist in an abstract form, and in most cases never get conceptualized and operationalized into tangible goals. Carter and Fortune (2007) identified gaps between sustainability policy systems in practice, and the lack of common structured evaluation frameworks to assist practitioners involved in the delivery of sustainable development projects. They related the difficulty of applying the principles and features of sustainability in a number of policy frameworks developed to date to either being the lack of basic features or being overly complex for practitioners to understand. According to Van Bueren and De Jong (2007), too much emphasis has been placed on "substance" to the detriment of "processes" needed to implement the policies, as a result, making it very difficult to incorporate suitable socio-economic benefit analysis into the evaluation frameworks. While a variety of different initiatives and policy frameworks exist for environmental and sustainability evaluation, however, to date, there is no consensus as to how to measure sustainability performance of a building project. Kaatz *et al*, (2006) called on policy makers and construction industry practitioners to reassess and redefine the environmental and sustainability indicators of building evaluation frameworks and policy systems, both on conceptual and operational levels within the built environment. The basis for such calls is to provide the means by which sustainability evaluation can be incorporated into the policy systems and frameworks to inform and direct the decision making processes. Kaatz *et al.* (2006) indicated that the integration of sustainability thinking into policy systems and decision making processes could form a basis for identifying synergies and making the most out of the imperative to achieve the performance objectives. It is also argued that any evaluation framework that sets out to measure performance must be well established on sound sustainability policy structures, with generally accepted criteria and methods to address the socio-economic challenges in an integrated manner. An appropriate and relevant framework needs to be developed based on project realities. An integrated approach to sustainability evaluation that takes into account socio-economic development at all levels of human development is more likely to promote sustainable development. Also, a policy framework which defines the sustainable regeneration agenda would have a great impact in creating and changing the awareness in getting policy makers to recognise the linkages between the socio-economic development and wellbeing of the society.

3. Discussion of Preliminary Results

It is widely acknowledged that different contributors have identified and classified socio-economic factors in diverse ways. However, from a built environment regeneration perspective, the socio-economic factors can be seen as vital concerns which are central to the effective and successful implementation of sustainability within regeneration projects. A preliminary exploratory study was undertaken by interviewing seven (7) key stakeholders drawn from the major leading construction organizations involved in sustainable regeneration projects in the UK, as shown in table 1 below. The objective of the study was to explore the state of the art in early stage evaluation of sustainable regeneration projects and how in particular the socio-economic sustainability factors were being articulated and evaluated during the early stages of projects. The interviews were structured around a range of open-ended questions to explore the issues under investigation. The exploratory nature of the questions helped to identify the issues and the limitations in the current practices related to early stage evaluation of sustainable regeneration projects.

Table 1. Profile of leading industry organizations interviewed.

Interviewee	**Position**	**Type of organization**
1	Director, sustainability/regeneration	Contractor organization
2	Director, sustainability/regeneration	Contractor organization
3	Senior Manager, sustainability/regeneration	Contractor organization
4	Senior Manager, sustainability/regeneration	Contractor organization
5	Director, sustainability/regeneration	Contractor organization
6	Director, sustainability/regeneration	Contractor organization
7	Senior Manager, sustainability/regeneration	Contractor organization

Sustainability Factors

The first interview question put to the interviewees explored their organizations' understanding of sustainability and the importance the practitioners and their organizations attached to such sustainability factors when evaluating project viability. A significant theme that emerged from their responses was the lack of conceptual clarity of what are 'sustainability factors' by the respondents. All the interviewees provided relatively simplistic definitions and understanding of sustainability in relation to their business operations. Typical of the comments made were as follows:

"*Sustainability is something ingrained and inherent in the business processes – something that the business has to pay attention to in order to stay competitive"* (Interviewee 1).

"Sustainability is embedded in our business operations. It is about protecting our business from the risks of today and ensuring that we respond to the challenges and opportunities that tomorrow brings…" (Interviewee 7).

The responses highlighted the limitation in the practitioners' perception and understanding of sustainability. The ambiguity of what constitutes sustainability was also identified as a major problem by Brandon and Lombardi (2011) and Evans and Jones (2008).

Sustainable regeneration objectives and benefits

When the practitioners were further asked about their understanding of the main objectives of sustainable regeneration projects, the respondents provided mixed responses. Some interviewees commented:

"*To achieve decontamination, re-use site soils in a sustainable manner and create the proposed landform that will enhance public amenity and wildlife biodiversity"* (Interviewee 5).

"…To ensure comfort and safety. To be aware of the social and physical environment and to endeavour to improve the quality of life to residents" (Interviewee 3)

Discussing the issues further about the benefits to their organisations and the end-users, most of the respondents indicated that company reputation was the main benefit for adopting the sustainability principles by their organisations. However, from an end-user perspective the majority of respondents were of the opinion that cost savings on fuel bills was the main benefit to the end-user.

Evaluation and evaluation framework/mechanisms

According to Kazmierczak *et al*., (2009), the evaluation process provides an effective management mechanism on which decision-makers can base their judgement in a variety of ways. In exploring the evaluation mechanisms currently in practice, many of the interviewees indicated BREEAM as being the main evaluation mechanism used for their projects. As some interviewees noted:

"BREEAM is the main assessment method used for our projects as it focuses on low or zero carbon technologies and designs"…It is a vital part of our culture and scheme to promote the adoption of cohesive sustainable solutions across all our specialism as a best practice to meet our sustainability objectives" (Interviewee 2).

"…BREEAM is easy to use as it provides a guideline and specifies the environmental impact of the final products. Their ultimate benefits are recognisability in a sense that they tend to capture the main environmental aspects of projects…Compliance with the existing environmental legislation and principles and best practices" (Interviewee 7).

Evidence from the responses showed that most sustainable regeneration practitioners still consider environmental factors as the most dominant feature of sustainability and they tend to neglect the consideration of any socio-economic factors. Most of the respondents emphasized on the environmental credentials of BREEAM and also regarded its application as representing the industry's best practice relating to sustainability. It is worth noting that BREEAM parameters are prescriptive in nature and largely based on quantitative assessment which tends to ignore the processes and issues relating to socio-economic factors of sustainability of the projects. This finding is also consistent with the earlier work done by (Essa and Fortune, 2008). When asked further about just when the evaluation frameworks were being applied during the project life cycle, there were mixed responses. Some of the interviewees noted:

"This varies from project to project. If our property business is involved then we are involved at concept stage through design and construction. Most of the time we would be contracted at RIBA stage D and E" (Interviewee 3).

"Ultimately it depends on the nature and duration of the project…" (Interviewee 2).

In addition, another interviewee who alluded to the use of an evaluation model commented:

"We do not have a structured evaluation framework per se, what we do have is some models for planning and benchmarking…Yes we tend to apply our models throughout our project duration to identify and address actions as soon as possible where the greatest sustainability impact may be available…This provides our sustainability team with a brilliant opportunity to look at a broad range of performance issues against the set of our sustainability targets and benchmarks" (Interviewee 6).

These responses however revealed the lack of a structured evaluation framework and an appreciation of early stage evaluation mechanisms for appraising the direct and indirect socio-economic benefits/impacts of their sustainable regeneration projects.

Socio-economic impact/benefit

Finally, when interviewees were asked for their views about the socio-economic impacts of their sustainable regeneration projects on the communities, a significant misconception emerged between sustainable regeneration projects and community redevelopment and renewal projects. Although all the respondents interviewed were involved in sustainable regeneration projects, their responses indicated a limited knowledge of socio-economic aspects of sustainable regeneration projects. This was demonstrated by the comments given by some of the interviewees as:

"Remediation of an existing hazardous environment in a sustainable way. Creation of public amenity, the improvement of public access on site and improved existing wildlife habitats that will encourage greater biodiversity on site. Redevelopment of site for use of both commercial/residential and public open spaces" (Interviewee 4).

"It is the social and economic impacts that we find most problematic. Our main goal across all our disciplines is to take a responsible attitude toward renewal of our communities. We are keen on providing modern community facilities, improving the physical environment of our communities as well as safeguarding the environment as a whole for the benefit of our communities" (Interviewee 5).

Many of the interviewees expressed their views in line with the potential environmental benefits of a project and also gave emphasis to sustainability factors that fitted within their own understanding and agenda (Evans and Jones, 2008). The limited consideration given to socio-economic factors in practice was also identified by a study carried out by (Carpenter, 2011).

4. Conclusion

This paper explored the early stage evaluation of socio-economic benefits of sustainable regeneration projects in the UK and presented the findings from an exploratory study that used semi structured interview approach to collect data. The study identified a disparity between the sustainable regeneration practices and the understanding and perception of sustainability factors on a personal and organisational level. The main finding from the study established that the consideration of sustainability was still viewed as being concerned with environmental issues by built environment professionals to the neglect of the socio-economic factors of sustainable regeneration projects. Another major limitation that was identified in the interviews was the lack of any existing early stage evaluation frameworks and mechanisms for evaluating the direct and indirect impacts/benefits of socio-economic factors of sustainable regeneration projects. The findings also identified that while all the interviewees seemed to have accepted the sustainability concept in principle; their responses indicated a lack of appreciation of the wider meaning and understanding of the composition of sustainability. This exploratory work forms the basis of on-going research which is concerned with the development of a framework for the early stage socio-economic benefits evaluation of sustainable built environment regeneration (SEBER) projects.

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Living in a Heritage: Sense of Pride and Inconvenience

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Abstract

Oxford, a city having a long development history, is full of monuments, listed buildings and conservation areas. The City of Oxford had approximately 9.5 million visitors and drew £770 million income in 2010. How do the residents perceive the heritage in Oxford? Living in a heritage can be a pride of and/or inconvenience to the residents. This study explores the perception of the residents of Oxford on the value of their heritage, in particular whether living in a heritage brings a sense of pride and/or inconvenience. The study therefore includes (1) defining heritage, (2) investigating the relationship between heritage value and knowledge of the heritage buildings and (3) collecting residents' views on sense of pride and/or inconvenience. Questionnaire survey was conducted to collect data from residents of Oxford. Statistical Package for the Social Sciences (SPSS) was used for data analysis. The findings show that (1) the heritage value of Oxford is highly rated despite the residents' knowledge in the historical and architectural background of heritage is not rich; (2) the residents are proud of living in Oxford; (3) they are also fairly satisfied despite the convenience arising from the restrictions on the heritage. Heritage of Oxford provides important cultural attachments to the residents. The findings also highlight the importance of preserving the distinct cultural atmosphere whilst allowing appropriate development of the city.

Keywords: Oxford, sustainability, heritage, pride, inconvenience

1. Introduction

Heritage has become important tourist spot and brings significant economic return. In recent years, the popularity of cultural heritage visits has increased as more and more people are having interest in experiencing other cultures. Oxford, a heritage city, is distinctive for its art, medieval architecture and language, attracted around 9.5 million visitors annually (3 times of the Oxford population, Euromoniter International 2007) with the associated £770 million of income for the local businesses (Allen *et al.* 1988; Oxford City Council 2011). Oxford has a total area of about 46 sq. km (17.6 sq. miles) (Oxford City Council 2011). The usual resident population of Oxford is about 153,700 and 26% of the population is student by 2011 (Oxford City Council 2011). There are two governmental authorities responsible for heritage conservation in the United Kingdom (UK); the Department for Culture, Media and Sport (DCMS) and the Department for Communities and Local Government (CLG). The duties of the former include heritage legislation, identification, conservation and enhancement of the historic environment. It is also responsible to compile a list of buildings of special architectural or historic interest and a schedule of monuments of national importance. The latter is responsible for protecting the historic environment through conservation planning, enforcement and development control. Historic Building and Monuments Commission for England (English Heritage) is an executive non-departmental public body which is actively involved in the preservation of the historic environment in the United Kingdom by providing the National Heritage Memorial Fund (NHMF) and the Heritage Lottery Fund (HLF). There are three broad categories of historic environment; (1) scheduled monuments, (2) listed buildings, and (3) conservation areas. There are sixteen conservation areas, over 1500 listed buildings, and eleven scheduled monuments (Oxford City Council 2011). In the central area of Oxford, over 900 buildings were built in a range of mid-eleventh century to the early twentieth century. They are included in the statutory list of buildings of special architectural or historic interest compiled by the government (Kersting and Ashdown 1980). For example, University of Oxford, the city's most functional heritage, is the oldest university in Europe (Tyack 1999). The university becomes academically important since the 12 century. The monumental university and college buildings with the more humble historic houses of the town constitute the visual, unique and complex character of Oxford. Oxford contains the only major survivals of medieval academic and university buildings that are still in use for their original purposes.

Adopting the general principle of traditional economic theory, the economic benefit derived from heritage visit can be calculated by the value of all visitors' willingness to pay for the enjoyment of visiting the heritage, for example an entry fee, to gain access to the site (Towse 2011). However, sightseeing in Oxford is typically not an "excludible activity". The heritage sites are indivisible and provide visitors with potentially identical joint and non-rivalry views. It is impractical to charge admission to a living part of the city. Thus, a cost-and-benefit analysis from a non-market valuation is especially relevant to the heritage in Oxford. The benefits of heritage are typically divided into "use" and "non-use" values. The former is those benefits derived from the direct and/or indirect use of a heritage site and the latter is those benefits associated with the heritage preservation. Maintaining sustainability of heritage requires not only the opportunities for tourists to learn about and experience cultures but also the willingness of the residents to contribute in the process by sharing their culture (Driver 1996).

The study provides insight to the suggestion of a specific investment in a heritage that has a positive net benefit from the social perspective. In particular, activities of heritage visit in Oxford bring pride and inconvenience to the residents (Keogh 1990; Johnson *et al.* 1994). These activities include looking around at the traditional architectures, shopping for traditional handmade goods, participating community festivals and watching academic ceremonies. The residents who are proud of their heritage are more likely to be reciprocating, tolerant, and motivated to community goals. Oxford is projected as an education city and this aspect has been promoted selectively at the expense of others (Hughes and Allen 2005). The local culture reflects an intrinsic relationship with the land shown through the reliance on an academic lifestyle. Huge numbers of visitors, transformation of heritage into museum and stringent measures on heritage preservation cause disturbance to the local residents (Ashworth 1992; Robinson 1999; Williams 2003). Many residents have been restricted in associated developments of their properties to retain their culture. Sometimes the living standard of the residential is devalued to preserve the authenticity of heritage. For this reason, some observers view heritage visit as another form of cultural invasion (Imrie and Kumar 1998). A trade-off analysis is proposed to study the pride of and inconvenience caused to the residents living in heritage. In the research plan, this study first seeks to learn what cultural benefits the residents feel they gain from heritage of Oxford, especially pride generated through the heritage visit. Then, another specific objective of this research is to document the inconvenience perceived by the residents in Oxford.

2. Sense of Pride

Heritage pride is defined as the extent to which the residents feel a mild positive emotion of respect, an achievement-related affect and worth, elicited by the presence of heritage in the form of cultural or national elements (Maldonado et al. 2008; Lea and Webley 1997; Sullivan 2007). Pride depends on a favourable outcome that is attributed to the city's characteristics (Lea and Webley 1997; Sullivan 2007). Tourists are interested in the culture of Oxford and this gives pride to the residents. The communities of Oxford are rich in cultural heritage and provide tourists with a wide variety of recreational and cultural opportunities. Historic sites, cultural centres, and other attractions allow tourists to interact with local residents, learn about and experience the culture. The forms of benefit can be categorized as economic, environmental, physical, psychological and sociocultural. Traditionally, heritage visits have been used as a method for enhancing economic stability, while the role of heritage visit plays in providing pride to the local community has not been fully explored (Driver 1996; Johnson et al. 1986; Kraus 1997), for example, sociocultural benefits on learning, awareness, appreciation, family bonding, a firmer sense of ethnic identity, increased understanding, tolerance of others, and stronger cultural identity (Driver 1996). In the current study, sense of pride can be realized by the host communities from tourists who visit their heritage. This interrelation between the residents and the tourists fosters a cross-cultural communication and promotes mutual understanding (Mathieson and Wall 1992). The act of presenting one's culture to outsiders strengthens the pride to live within a community, thus increasing (1) social identity, (2) social connectedness, (3) social support, (4) social continuity and (5) social wellness (Clements et al. 1993; Delamere and Hinch 1994).

2.1 Social identification

Heritage pride induces a sense of social identification that the residents value their belonging toward the inherited. The community residents are proud of their differences and celebrate an independent identity (Esman 1984). They speak their traditional language and practice the custom of their forefathers. The residents appreciate their place which is distinct globally. This identity is inseparable from its superiority (Palmer 1999). In identifying with their heritage, the residents actively share with friends of the same ethnicity and prefer to engage in their inherited social activities (Padilla and Perez 2003). If properly managed, the legacy of heritage will continue to contribute to the overall image and to the economic potential of the community.

2.2 Social connectedness

Social connectedness is the residents' association with a collective social pattern, belief system and esteem (Harrison 2010). The cultures can be accumulated and understood in terms of a series of processes by which new and old practices are adapted and adopted. The acculturation change is delayed when the residents are strongly connected with their social network (Padilla and Perez 2003). It allows better cohesion, interaction, togetherness, sharing of ideas, and inclusiveness within the community.

2.3 Social support

Social support refers to power of heritage as a commercial operator in their advertising. Heritage listing provides certainty for owners, neighbours and intending purchasers in their investment. Heritage has positive impact on property values by providing a form of insurance of future neighbourhood. In most cases, heritage is associated with higher property values (Leichenko *et al.* 2001:1973). Listed heritage also enable the residents to access to heritage valuations, concessions, grants and loans provided by governmental and non-governmental funding.

2.4 Social support

Social continuity refers to the perpetuation of the culture. Tourists are attracted to heritage because it provides the opportunity to step back in time and ensures continued earnings from heritage visit (Besculides et al. 2002). Traditional craftsmanship are revitalized and protected against rapid acculturation (Esman 1984). The local residents also practice more about those disappearing acts by presenting them to visitors. Thus, there is both a renewal of identity and an increase of pride in one's own culture (Besculides et al. 2002; Esman 1984). The high level of acknowledge of the residents on their exotic culture ensures its perpetuation.

2.5 Social support

Social wellness refers to the harmony created from the heritage. The call for integrating heritage preservation extends the town planning principle to landscapes, villages and the environment as a whole. This principle imposes restriction on the development of the community, defers premature constructions and results in less pollution (Kleinitz and Näser 2011). For example, height restriction prevents the punctuation of skyline by tall buildings.

3. Inconvenience

Heritage is valuable structure that, by nature, should be changed as little as possible. The restrictions and limitations in modifying heritage cause inconvenience to the residents. The residents have to carry out regular repairs, maintenance and restoration of heritage. The criteria on structural effectiveness, cost, compatibility with the techniques and materials used are taken into account not to affect the authenticity of heritage and its associated value. Thus, inconvenience is connected to (1) upgrades and maintenance, (2) health and safety, (3) social disturbance, (4) space utilization.

3.1 Upgrades and maintenance

The inconvenience caused by upgrades and maintenance refers to a lack of adaptability of heritage to modern precision mechanical systems (Descamps et al. 2011). Upgrading services in heritage is problematic. The installation and removal of services harm the authenticity of heritage. The tradeoff in heritage preservation is between residents' living standard and heritage authenticity. For example, the installation of air-conditioning system is prohibited in the University of Oxford except for the laboratory in order to maintain its integrity. The build environment is substandard and disable-user unfriendly, like steps or restrictions on entry to buildings, which serve to exclude or produce discomfort or nuisance (Imrie and Kumar 1998:358; Golledge et al. 1993). For example, many of the heritages in Oxford are communicated by means of staircase while vertical transportation like lift and escalator are absent. These built environments prevent disabled people's mobility while restricting their access to specific places (Imrie and Kumar 1998; Golledge et al. 1993). Special requirement are also imposed to owners and tenants of heritage. For example, Oxford City Council (2011) states that "lighting is important and can add interest to a building and help to display the quality of its architecture". Thus, additional lighting is provided at night to make the night-time streetscape more attractive and support the vibrancy and vitality of the community. However, the lighting increases operation cost, energy wastage and pollution (Evcil 2009:76; Gallaway et al. 2010:658).

3.2 Health and safety

Health and safety issues refer to the harms caused by substandard building elements of heritage to health and safety of the occupants. For example, flooding and snowstorm are two of the major disasters in Oxford (Yoshikoshi 2011). The Thames and Cherwell Rivers floodplains cut through the centre of Oxford. The ability of heritage to resist the force majeure is relatively weaker than modern buildings. The deprived interior fittings such as sanitary appliances, old stoves and electrical fittings which have intrinsic historical significance and may be worthy of preservation or rescue, but preservation of these fittings are problematic (Sharpe 1999). The restriction in modification implies tradeoffs of the residents' standard of living

3.3 Social disturbance

Social disturbance refers to the drawback of tourism brought to the community. The increase in non-residential population contributes to noise, congestion, crime, inflation, family structure; a unidimensional economy; and resentment which disrupt the peace of the community (Allen et al. 1988). In the high season, infrastructures reach their limits. For example, the environment is overcrowded and the traffic is congested (Sheldon and Var 1984:40). Many heritage sites have experienced large amount of visitors and threat to the actual physical fabric has been created (Graham and Howard 2008). Tourism is also partly responsible for an increase in security problems as wealth of tourist area is especially tempting to robbers and burglars (Croci 1998; Sharpe 1999).

3.4 Space utilization

Space utilization refers to the limited use of space. The major public transports in Oxford are bus, railway and taxi. The limited in living space, parking space and tighten traffic condition call for relief measures such as (1) parking on the outskirt of the city and travelling around Oxford by bus, (2) restricted access of cars within Oxford city centre particularly for traffic coming into the centre from the East, along the High Street (Oxford City Council 2011).

4. The study

The aim of this study was to investigate the views of residents on Oxford being a heritage. The objectives are to determine their views about the pride and inconvenience of living in heritage. Data on the residents' sense of pride and inconvenience were collected in a questionnaire study. The questionnaire consists of five sections includes statements collecting (1) personal information, (2) knowledge of Oxford Heritage, (3) view on heritage value, (4) pride and (5) inconvenience. Respondents were asked to rate their level of agreement on the statement on a 7-point-Likert scale (1: strongly disagree to 7: strongly agree). Target respondents were those who were living in heritage in Oxford and their contacts were obtained from local directories. 301 sets of questionnaire were sent to respondents by email and 80 completed questionnaires were collected which give a 26.6% response rate. Data was then evaluated and analyzed using Statistical Package for Social Science (SPSS). In the first section of the questionnaire, demographic data of the respondents includes name, gender, age, resident status, year of stay, etc. 51.25% of the respondents are female. The average age of the respondents was 29.47 year-old (SD=8.21 years). On average, the respondents had spent 6.68 years (SD=4.81 years) in Oxford. 77.5% and 15% of the respondents were non-local residents and property owners respectively. 33.75% of the respondents showed their concern over the heritage policy and most of the respondents did not experience restriction in renovating their property (92.5%). Walking (53.75%) and cycling (28.75%) were the most common modes of transport. Respondents found that upgrading internet (30%) and window (23.75%) elements were most problematic. 14 questions were used to test the residents' general knowledge of heritage in Oxford. Those questions include the grade of Christ Church Cathedral, the year of establishment of Tom Tower, etc. The average marks were 3.21 (SD=2.21). The result shows that the residents do not have sufficient knowledge about their heritage.

5. Resident perceptions on heritage value, pride and inconvenience

The respondents valued the heritage of Oxford highly (μ=5.48, SD=1.68) even they did not have accurate knowledge on the heritage. The result is different from Timothy and Boyd's (2003) works that residents having in-depth understanding and knowledge of their heritage are more concerned of their heritage. Thus, it is suggested that an in-depth knowledge should be created among the public by mass media, education and personal experiences. This can also help local residents to engage in the realm of history preservation and become educated or more closely connected to their own past (McIntosh and Prentice 1999), foster visitor appreciation of a site, and create public support for conservation of heritage (Moscardo 1996). In respect of historical value of Oxford, residents think that the long-standing history (μ=5.64, SD=1.91) and architectural features (μ=5.24, SD=1.54) reflect the historical value of Oxford (μ=5.24, SD=1.54). Not all buildings become heritage because merely by being old. Every heritage building has its unique features and this is one of the attributes deriving heritage value. The unique features of heritage properties include distinctive façade, architectural features and general construction of the distinctive quality and ambience keeping with the traditional way of life of the area (Bhatia 2006). The heritage of Oxford is a built form that gives the area uniqueness, character and distinctiveness (Hunt and Worthen 2006).

Residents felt pride living in Oxford (μ=5.22, SD= 1.48), but they did not acquire the knowledge of the heritage through reading and sharing (μ=3.65, SD=1.494). Rose (1995) suggested that "One way in which identity is connected to a particular place is by a feeling that you belong to that place. It's a place that you feel comfortable, or at time, because part of how you define yourself is symbolized by certain qualities of that place" (Rose 1995; Graham and Howard 2008). Heritage is a powerful tool for promoting identification with the past and locating oneself within wider networks of memory. The history and memory are the priceless property owned by the local residents. "Moreover, a 'sense of place' relates to the socially constructed perceptions and beliefs' that individuals or groups hold about a particular location (Graham and Howard 2008). Many of the respondents were going to leave Oxford (61%) due to high mobility of students (72.5% in the survey). McCool and Martin (1994) found that residents who were strongly attached to their community viewed heritage value impacts with more concern than did those less attached to their community. There were widely divergent views on heritage value between newer and longer term residents (Stynes and Stewart et al. 1993). The former favours further development, while the latter did not and were concerned about potential changes in the area's character as a result of such growth. Conversely, Allen et al. (1993) and

Clements et al. (1993) found that length of residence did not have a significant effect on attitudes toward heritage value. In the current study, it is suggested that length of residence in an area has less influence on resident perceptions of and attitudes toward heritage value. “Heritage buildings, locations and associations, together with the products, events and experiences produced from these, bring an aura of respectability, continuity and artistic patronage to a city” (Graham and Howard 2008). “Clearly, it is an economic resource; one exploited everywhere as a primary component of strategies to promote tourism, economic development and rural and urban regeneration”.

Oxford is fairly convenient in the eyes of the respondents (μ=4.67, SD=1.59). The disaster resistance of heritage is fairly satisfactory (μ=3.90, SD=1.53). The respondents agree that there is an insufficient accommodation for the increased population (μ=4.47, SD=1.13). The heritage price is higher than that of non-heritage (μ=4.35, SD=1.63). Economic dependency on heritage and proximity to attractions can also influence resident perceptions. The relationship between residents’ acceptance of the industry and their economic dependency on it is positive (Allen et al. 1993; Jurowski et al. 1995; King et al. 1993). It is suggested that residents benefited from tourism are more likely to encourage heritage value than those not. In contrast, even while the overall attitudes toward heritage value are positive, residents living in close proximity to heritage value can have greater concern about the resulting impacts than those living further away (Keogh 1990; Wall 1996). The respondents rate the accessibility of heritage less satisfactory (μ=3.69, SD=1.46) even the subsidy for maintenance of heritage has been provided (μ=4.18, SD=1.217). There are also insufficient parking space (μ=3.18, SD=1.69) and travelling lanes for bicycle (μ=3.96, SD=1.23). The living standard of heritage fails to reach the expectation from the residents’ point of view (μ=3.78, SD=1.35). The residents experienced conflict between their living and the intrusion of visitors. Further research is suggested on the acceptability of cultural tourism events and facilities that could occur within local communities in Oxford to benefit both host and guest.

The benefits of preserving heritage ultimately accrue to individuals in Oxford, from owners of the properties to the general public at large. These may be tangible (e.g. market values) or intangible (e.g. enjoyment of the aesthetic appeal of the heritage) (Productivity Commission 2006). A successful heritage conservation system should provide adequate incentives to individuals to undertake appropriate conservation activates, thus, the associated benefit outweighs the associated costs. The benefits and the costs can be dynamic. The inability to accurately measure the benefits and the costs makes the attributes inclusion in a cost-and-benefit analysis problematic from an economic perspective. In this study, members of the community were surveyed to obtain the non-market valuations placed on the pride and inconvenience living in Oxford.

6. Conclusion

The purpose of this study is to investigate the views of the residents of Oxford on being a part of the heritage. The issues that were studied include the residents’ (1) knowledge of the heritage, (2) perception of the heritage, (3) sense of pride and (4) feelings of inconvenience. The study uses the data collected in a questionnaire survey to explore the residents' perceptions of the pride in and inconvenience arising from living in the heritage city of Oxford. The sense of pride is strong and living in Oxford is fairly convenient. These findings assured the value of heritage in Oxford and highlight the importance to proper manage and maintain the heritage values. Further researches are suggested in this regard. What are economic cost and benefits of a heritage building? How can owners charge occupiers or visitors for use of heritage? Approximately 40,000 non-residents travel to work in Oxford - around half the city's workforce. This suggests that the daytime population is boosted by approximately 26,000 due to travelling workers. They have a lack of knowledge about the heritage and inactive in utilizing heritage as a resources of knowledge sharing and economic vehicles. Through proper planning and management, the incentive not only improves the quality of life of the residents as well as to enhance the sense of place to these two groups of population. When there is a market for heritage, the heritage is promoted and possibly saved from demolition.

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A warehouse of heritage value: a case study of the Catholic Cathedral of the Immaculate Conceptions in Middle-Level, Hong Kong

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Abstract

There are a growing number of advocates preserving heritage which is important to a sustainable society. This paper draws on heritage literature to define a set of attributes amount to value of heritage trail. These attributes are identified as important measures to examine the value of heritage, in particular, the case study of the Hong Kong Catholic Cathedral of the Immaculate Conceptions (the Cathedral), the Central route of the heritage trail, Hong Kong The investigation revealed that the potentials for conserving the Cathedral valued highly in the heritage trail and there are diverging views by various stakeholders. The differences are attributed to the understanding of the heritage trail and the issue of authenticity. The implications of the study provide suggestions for future improvements in the development of heritage trail.

Keywords: sustainability, heritage, historic value, architectural merit, social value

1. Introduction

Old buildings are often regarded as obsolete and typically subject to clearance and comprehensive redevelopment (Power 2008). Moreover, preservation has become another option for buildings of value. The presence of protected buildings however pose restrictions on what could be done with the neighbourhood, in particular where such spaces are not of similar character. Therefore, the intent of conservation must harmonize with the need for a healthy socio-economic base in the community. Furthermore, the value of heritage differs among the potential users and the general public. Heritage refers to buildings which, because of their architecture, their homogeneity or their place in the landscape, are of significant value (UNESCO 2011). It involves the development of touristic activities on man-made sites, architecture, housings and landscapes that originated with socio-economic development processes of earlier periods. The subjects of heritage also encompass the fixture, such as plants, products, machinery, equipment and documentation (Xie 2006). In Hong Kong, the natures of heritage have varied from traditional Chinese culture, colonial culture to cosmopolitan culture as tourist attractions. Examples of heritage in Hong Kong, among many, include the Tai Fu Tai which is the opulent residence built by a scholar who was bestowed the title of Tai Fu (mandarin) by a Qing emperor, Tang Chung Ling Ancestral Hall which has been built in honor of the Tang clan's founding ancestor and Man Mo Temple which is dedicated to the gods of Man (literature) and Mo (martial arts).

The increase in popularity of heritage visit is attributed to the growing globalization of society and declining links with traditional customs. Culture tourism gives tourists nostalgic and novel experiences. In addition, by stressing the value of local cultural past, the touristic activities enhance the residents' identity and encourage localization as well. Heritage visit is also a vehicle to improve regional image and to function as a public relation tool to counteract public prejudice against preservation (Besculides et al. 2002). There is a growing support that heritage visit is instrumental for social capital restructuring (Aas et al. 2005; Tiesdell et al. 1996). The increasing popularity of heritage visit has been viewed by many to be a mixed blessing for the host community because benefits and inconvenience coexist. Heritage visit is often cited as a means to offset the effects of economic restructuring and raise the tourist profile of the city and regions. In reality, the economy dependent upon heritage visit appears to be limited, because related employment can rarely compensate for the loss of profit resulting from the redevelopment of land in Hong Kong in full (Hui et al. 2008). Despite the developments described above, the foci of heritage visit are quite narrow in scope (Henderson 2002). Little empirical research has been under-taken into the impact of heritage visit in promoting morale across local communities (McLean and Cooke 1999). The shift of landscapes from livelihood to tourism spots involves fundamental changes in the local communities. It involves certain level of adoptive reuse and includes change or expansion in its function, from being fully or partly utilized to a new functional purpose much different from its original and/or present use (e.g. museum). It is important that the originality of the heritage visit is valued and is incorporated into plans that benefit its new function. Thus, there is a growing literature on the development of heritage visit from urban planning and architectural perspective. For example, Machado et al. (2009) interpret heritage visit from educational or archaeological perspective and emphasize the protection and care for the irreplaceable elements of the community, restoration of buildings, grounds, machinery, and processes, and developing new uses for redundant elements of the local landscape. The success of maintaining high heritage value is based on broad principles of conservation and building incrementally on surviving resources in terms of buildings, landscape, and people in regenerating works (Aas et al. 2005). The principles emphasize the significance of creating a sense of place which is unique, imaginative, authentic, sustainable, and public participative (Leary and Sholes 2000). A comprehensive heritage value evaluation thus becomes crucial in developing a heritage visit. This paper first identifies key attributes of heritage visit from literature (AMO 2012; Australia ICOMOS 1999; China ICOMOS 2004; English Heritage 2008) Then, these attributes are used to evaluate the heritage value in a case study of the Hong Kong Catholic Cathedral of the Immaculate Conceptions (the Cathedral), the Central route of the heritage visit, Hong Kong through interviews and questionnaire survey studies (Figure 1).

Figure 1: Axonometric view of the cathedral

2. Key attributes of heritage

2.1 Historic value

"What the site has to tell us about the course of human history, or the history of a group or culture. The site may conserve important physical fabric or other evidence of the past. It may be associated with important events and developments of people." (Australia ICOMOS 1999) Historic value serves to assess the characteristics of heritage and to make a sound decision about which tourism programs to invest in. The major purpose of heritage is to provide residents and visitors "with which to continually interact, one which fuses with the present" (Lowenthal, 1985:410). Heritage has close historical association with the cultural development of the community that (1) effectively illustrates important aspects of the social, economic, cultural, industrial or military history of the community, or (2) bears a significant testimony to a cultural tradition, a culture or a phenomenon which is living or which has disappeared. In a broader historical context, the linkage can be between heritage and (1) persons, (2) events, or (3) archaeological potential. Thus, heritage that physically and/or visually associates with one another provides richer historic value.

2.2 Architectural merit

Architectural merit is"…a demonstration of a particular design, style, artistic development or high level of craftsmanship" (Australia ICOMOS 1999). Architectural merit demonstrates the value of architectural design, plan forms, decoration, craftsmanship, construction techniques or use of materials/fabric of heritage. High score in architectural merit should be accorded to group of buildings exhibiting an important interchange of styles, over a span of time or within a cultural area, on developments. Authenticity, integrity and rarity are added features to architectural merit of heritage. Authenticity is an ability of heritage to convey its significance over time. Authenticity is seen as the "opposite of generic" or genius loci. An authentic heritage has undergone little modification and retained most of its original features, materials and characters. Alterations and additions at a later stage should not detract from the original architectural expression. It can truthfully and credibly express its cultural value. Thus, the heritage gives visitors the spirit of place and an area's most important aesthetic attribute (Florida 2002:228). Integrity is a measure of the wholeness and intactness of heritage and an ability of heritage to secure or sustain its significance over time. Thus, the physical fabric of a heritage and/or its signature features should be in good condition, and the impact of deterioration processes under control. Rarity refers to the uniqueness of heritage in architectural style, purpose, function, details, type, convention, age, assembly use of building materials, construction elements or method, etc. In some special cases, the architectural value is higher, when the heritage was designed by, or attributed to, a noteworthy architect, engineer, builder, craftsperson, landscape architect, or artist who has made a significant contribution locally and/or internationally. Deterioration, degeneration, annexes, renovation and modifications of the structure destroy the architectural merit of a heritage.

2.3 Social value

Social value is "the intellectual or emotional impact of a place. This may be the emotional association or mood of a site. ……The degree and the way in which a place is now or was in the past a focus of spiritual, political, national or other cultural activity to majority or minority groups" (Australia ICOMOS 1999). Social value of heritage is reflected by its significance as a visual landmark recognized by the community for characteristic, symbolic, spiritual, emotional or nostalgic reasons. This recognition is important in depicting the "cultural identity" and perpetuating the "collective memory" of the community. This collective memory is directly or tangibly associated with events or living traditions and customs, with ideas, or with beliefs. Heritage facilitates social solidarity through the shared sources of pride. The presentation of social value relies upon diversity of people who study, work, live or pursuit leisure in a heritage. These stakeholders may include local residents, business leaders and planners. At the community level, stakeholders include active members in the local organizations, supporters, and multiple audiences, or users of the facility. The collaboration among stakeholders to develop consensus for a destination development is becoming more and more important in maintaining the social value of a heritage (Bramwell & Sharman, 1999). Thus, de-socialization or detachment process of a heritage reduces its social value. From a socio-economic perspective, although heritage would "take advantage of its historic character, ambience, and sense of place" (Tiesdell et al. 1996:68), it has become an important economic means to minimize the losses associated with the changes in the local economy from livelihood (both environmental and community context) to tourist attraction.

3. Methodology

The decision to preserve the Cathedral involves the local community, development consultants and input from the public at large. The project itself is an overview of the planning process, an assessment of area market trends and opportunities, a physical development plan, implementation and design guidelines and a fiscal impact study. The present research was conducted in the Cathedral and surrounding Central areas. Data gathering and analysis were based on four stages as follows: (1) examination of documents related to the Cathedral. Government planning documents were examined to understand the issues of concern to planners in the region; (2) site visit of the Cathedral. It allowed the authors to examine the current status of the Cathedral and to experience those activities held by the Cathedral. (3) In-depth interviews with different groups of stakeholders associated with the Cathedral representing a broad array of interests and concerns. The prospects of the Cathedral and endeavoured to build consensus among the stakeholders; and (4) questionnaire survey were conducted to seek opinions on the Cathedral. There were open-ended and close-ended questions in the survey. Respondents were required to fill in their personal particulars and the answers examining their knowledge on the Cathedral in the open-ended section. Respondents were asked to rate their degree of agreement on the statements concerning heritage value of the Cathedral in the close-ended questions. The statements were scored on a 7-point Likert-type scale, where 1 represents strong disagree and 7 represents strong agree.

4. Findings

4.1 General

Interviewees included archivist of Hong Kong Catholic Diocesan Archives, director of Centre for Catholic Studies in Chinese University and senior maintenance surveyor in Architectural Services Department. Questionnaires were distributed in different time slots (weekday or weekend, and morning, afternoon or evening) to the users of the Cathedral, local residents, visitors and passers-by of the Cathedral. A total of 155 sets of questionnaire were delivered and 91 completed sets of questionnaire returned (58.7% response rate). Respondents had an average age of 36.43 year (S.D. = 16.99 years). 57% are Catholic and 43% are non-Catholic. More than 50% of the respondents have a degree or above education level. 76% of the respondents visited the Cathedral more than once per month. The purposes of their visit were mainly worship (61%) and sightseeing (29%). 72% of the respondents are residents in Hong Kong Island.

4.2 Historic value

According to the literature and interviews, the Cathedral was first built in 1843 on the slope at the junction of Wellington Street and Pottinger Street. It was engulfed by a great fire and burnt to the ground in 1859. In 1860, the Cathedral was rebuilt on Wellington Street. To cater for the problem of space inadequacy, the Cathedral has been finally relocated on the hill slope near the Glenealy Estate in 1888 which is now called the Caine Road. In the interviews, the interviews yielded a positive feedback considering the heritage value of the Cathedral. They agreed that the Cathedral is associated with high historical value and is irreplaceable in representing the colonial culture. Since the Cathedral is one of the largest and oldest Catholic churches in Hong Kong and it is now the head quarter of the Catholic community, it is no doubt that the Cathedral is the landmark Catholic Church in Hong Kong. The senior maintenance surveyor in Architectural Services Department described the Cathedral as "a cultural beacon, a recreation center, and a social hub". The Cathedral has the potential to not only bring visitors to the city, but to enhance social identity as well. The Cathedral can be seen as a place where people actively build and express their identities (McLean and Cooke 1999). The Cathedral brings together people who are interested in the history of Hong Kong and its impact and influence upon the Catholic community. In the questionnaire survey, respondents were asked for their opinions to identify the most important history value reflected by the Cathedral. Respondents rated the Cathedral as one of the most marketable heritage. The heritage value of the Cathedral rated by respondents is gradually increased from level of region of Hong Kong (μ=5.08, SD=1.60), the Central district (μ=5.68, SD=1.36) and Catholic Church (μ=6.59, SD=0.72). The views of the heritage value of the Cathedral are similar between Catholic and non-Catholic respondents except for the heritage value of the Cathedral with respect to the Hong Kong Catholic community ($\mu_{\text{non-Catholic}}$=4.18, SD=1.37; μ_{Catholic}=5.73, SD=1.43; F=26.57, sig.=0.000). In the questionnaire survey, respondents were asked to rate the historic value of the Cathedral (μ=6.42 out of 7, SD=0.76) and to answer questions (μ=2.42 out of 16, SD=2.561) about the history of the Cathedral; (1) chronology associated with local community, Catholic community and Hong Kong and (2) building age of the Cathedral. The result indicates a lack of knowledge of the Cathedral's history regardless of its highly rated historic value.

4.3 Architectural merit

The Cathedral is an elegant Gothic Revival style cathedral. It is designed by Crawlwey and Company of London. The Cathedral measures 82m in length and 40m in width, with a seating capacity of over 1,000. It rises to a height of 23.7m with an additional 10m for the central tower, which creates spacious feeling and allows better ventilation. The Cathedral has a cruciform floor plan in which the choir is oriented to the North and is different from the common East orientation of churches (Henry-Claude et al. 2001). Buttresses are used to support the structure of the Cathedral and reinforce the external walls which are laid on granite platform of 1m height and are constructed by bricks and stone (Figure 2a). The buttresses also give support to the heavy cast-iron beams and, in turn, the roof structure of the Cathedral. The roof of the Cathedral is doom-shaped and decorated with pre-cast iron bracing and wooden panels. Thirty-two granite interior pillars of 6m height are erected parallel to the external buttresses to form fifteen independent structural frames and have given rise to pointed arches supporting the timber and concrete pitch roofs. To express gratitude to people who have made contribution to the construction and renovation of the Cathedral, 28 memorial plaques acknowledging the donators are attached to the pillars. The transept cuts across the longitudinal nave and forms the “crossing” at the location of the main altar where the Bishop’s Chair are located and the relics of the ten saints are embedded. The central tower above the main altar is supported by four pillars of 10m height and 1.5m in diameter. At the top of the central tower, a number of openings allow more skylight entering the main alter as compare to the other part of the Cathedral. The simplicity and centrality of main altar make it a natural focal point of the Cathedral (Ha 2008) (Figure 2b).

(a) Buttress structure of the Cathedral

(b) Top of main altar of the Cathedral

Figure 2: Architectural features of the Cathedral

There are four chapels in the Cathedral, Blessed Sacrament Chapel, Mission Chapel, Chinese Martyrs’ Chapel and All Soul’s Chapel, form an annex to the Cathedral. The ante-church of the Cathedral is characterized by Gothic style porches with oculus, lancet and round arches. Non-load bearing wall structure of the Cathedral allows for large window openings. The stained glass windows of the Cathedral depict events in Catholic history and social development over time, for example, (1) Jesus and John the Evangelist at the Last Supper, (2) St. Catherine of Sienna, (3) St. Pascal Baylon and (4) the Appearance of the Risen Lord to Mary Magdalene, along the wall near the Blessed Sacrament Chapel, designed by the French artist Louis Gesta in 1923 and made in Italy. Statues of Saints of the Cathedral include the statue of the Immaculate Conception, Apostles, Bishops, doctors of the Cathedral, Popes and a King. The Cathedral has undergone 3 major modifications, (1) in 1937, replacement of roof due to part of the timber roof was blew by typhoon and central spire was also destroyed; (2) in 1969, internal modification after the Vatican II liturgical reforms; and (3) in 1923 and 1985, installation of new stained glass windows. For integrity, the Cathedral has continued its function of providing spiritual place for worship since its inauguration. For rarity, St. John Cathedral is the most similar to the Cathedral in architectural style and age. The result of the interviews and the questionnaire study suggested that the Cathedral forms an integral and distinguish part of the Catholic community. However, the harmony of the environment is deteriorating because of the growing numbers of high-rise buildings nearby (i.e. Caritas House, Robinson Heights Block and Reimondi College) (μ=5.36, SD=1.13). The surrounding buildings have blocked the panoramic view of the Cathedral. Apart from the external view, respondents considered the upgraded air conditioning system does not affect the architectural merit of the Cathedral (μ=2.87, SD =1.72). The respondents considered the preservation of the Cathedral as a necessity.

4.4 Social value

The Cathedral has provided various activities for different interest groups, not only the Catholic groups but also the non-Catholic groups, for example, caritas bazaars, parties for solitary elderly and English classes for children of local community. During 2009, the Cathedral served over 1300 people for the heritage guide tour. Russell (2010) mentioned that the vast majority of heritage studies do not involve social value in their analysis of heritage value. Social value is a complex mixture of intellectual and emotional perceptions and sentiment including sense of identity or memory inherently attached to a place. Both the interviewees and respondents agreed that the Cathedral is a catalyst in stimulating spiritual connectedness, social connectedness and harmony in the community (ΔR^2 = .81, sig. = .000). In the survey, respondents listed out at least one event held by the Cathedral like the Midnight Mass at Christmas, promotion of Priest and baptism. Mattison (2006) pointed out that conservation expert and politicians should take social value into consideration when assessing heritage value. He also notes that experts 'think' and 'know' heritage value, whereas people 'feel' and 'believe' heritage value." Undoubtedly, there is discrepancy between an emotionally motivated public and an unfeeling expert culture in determining the heritage value. There is always a central role for expert opinion in deciding which types of heritage goods will receive attention, while information about the general public's preferences over such decision is overlooked; besides, the public preferences is actually a useful supplement to expert judgment (Ready and Navrud 2002). Public policies are needed to designate and conserve heritage building in the interests of protecting social memory for the benefit of present and future generation (Hayden 1995). The nature of social value is far different from historic value and architectural merit, which is less dependent on the knowledge basis; social value is emotional perception which does not depend on related knowledge basis to 'think' and 'know', In measuring the social value of the Cathedral, The greatest difference between Catholic and non-Catholic in evaluating the heritage value of the Cathedral is found in social value (F=42.138, sig.=.000) as compared with those in historic value (F=11.860, sig.= .001) and architectural merit (F=3.246, sig.= 0.075). On the level of individual, people can become deeply attached to places in a way that is critical to their well-being; while at the level of group, certain places are significance because they trigger social memory (Teather and Chow 2003). All the activities provided by the Cathedral are not just by physical means, but also associated with spiritual and religious meaning to the Catholic community.

5. Research implication

Preserved heritage forms a linkage between individuals, place and culture, thus contributes a more desirable place to live (Ashworth and Graham 2005). Hong Kong has an area of 1,104km2 and a population of 7 million in which approximately 43% practice some forms of religion. There are, mainly, 8 religions currently practicing in Hong Kong including Buddhism, Taoism, Confucianism, Christianity, Islam, Hinduism, Sikhism and Judaism, in which about 350,000 followers of Roman

Catholic Community in Hong Kong. 104 catholic churches provide religious services and places for the followers of Roman Catholic to mass, but only a few of them are constructed solely for the purpose of mass or in the form of "church buildings". Religious buildings are important in raising sense of identity, cultural awareness and architectural aesthetic of the city. Some of these buildings are graded as historical buildings in relation to their heritage values. As one of the largest and oldest Roman Catholic Churches in Hong Kong, the Cathedral has contributed to the history of Roman Catholic in Hong Kong for more than a century. Undoubtedly, the Cathedral is a store-house of chronology and memory. Nevertheless, the limited number of informative publications on the Cathedral calls for the attention to review the heritage value of the building (LLC 2010). Defining the meaning of heritage is a prerequisite to the examination of heritage value of the Cathedral. Therefore, this research first starts with the definition of heritage value.

Heritage is the entire corpus of material signs, either artistic or symbolic, handed on by the past to each culture and, therefore, to the "landscapes of nostalgia" in which leftovers have been transformed into valuable assets for rejuvenation (Xie 2006). The preservation of the Cathedral appears to be constrained by a variety of factors: (1) the potential costs and benefits for the community; (2) the knowledge-based transfer of the history of the Cathedral; (3) its authentic presentation; and (4) local participation. Regarding the costs and benefits, the return of the investment dependent upon heritage visit appears to be limited, because related employment can rarely fully compensate for the loss of profit resulting from the redevelopment of land in Hong Kong (Hui et al. 2008). The relative low score of respondents in the historic questions of the Cathedral reflects a lack of knowledge transfer to the community. The heritage visit of the Cathedral has attracted a warm reception from the tourism industry and local business organizations. They believed that the inclusion of the Cathedral in the heritage trail would revive the area and boost economic return. However, some of the Catholic local residents have raised the concern over the possible disturbance brought from the tourism to the Cathedral. The resources of the Cathedral are limited especially spaces. The increasing number of visitors to the Cathedral may add burden to the heavy traffic system, while respondents suggested that the Cathedral should provide greater accessibility to the public.

The Cathedral exhibits two particular features; non-excludability and non-rivalry in consumption. The former means that users and non-users cannot be excluded from deriving a benefit from the Cathedral and the latter means that the admission of the Cathedral is not limited (i.e. there is no scarcity). These two properties significantly limit the incentive for the private and public sectors to preserve the Cathedral. Nevertheless, the findings suggest that the Cathedral plays an important role in developing social cohesion. The quality of urban life is a city's cultural activity, beyond job creation, tourism development and image improvement, which can generate community identity and pride (Fleming 1997:28). The community has acknowledged the importance of maintaining the Cathedral. Thus, the surrounding areas of the Cathedral have the potential to stabilize and revive through a combination of light touristic activities and preservation by means of cultural trail development (AMO 2012). The Cathedral encourages cultural activities and strengthens the character of the neighbourhood. However, such idea requires careful planning, long negotiation among various stakeholders, complex financial arrangement, and significant community participation (Falk 2000). The research result suggested that there is a fundamental distinction between the views of insider-participant and the external expert. The contribution of the study is on the objectivity in assessing the heritage value. The adaptive reuse involves public participation. The incorporation of social value in the wider heritage value achieves a more comprehensive review. The investigation also revealed concerns on the authenticity of the heritage. The respondents are aware that the Cathedral is unique, but they have not seen beyond this façade and comprehended the profound history and architecture of the Cathedral. Their perceptions on the authenticity of the Cathedral, in fact, will be a judgment or a value placed on the setting when the Cathedral is under renovation. To preserve and promote the profile of the Cathedral, it is suggested that local education program can engender better understanding of the heritage and advocate a proactive discussion of the potential benefits of the project.

6. Conclusions

Hong Kong is striving to improve its image and regenerate the local social tie through promoting cultural tourism. As part of the city revitalization, heritage visit has been proposed to raise the profile of cultural heritage in local, national and global history. This research presents an extensive investigation on the prospect of the Cathedral to meet these aims. Attributes of heritage value; historic value, architectural merit and social value, are identified as the major factors in determining the vitality of heritage. The findings suggest that the Cathedral contributes significantly to the community or character of the locality and is a distinctive, conspicuous, and familiar feature of the street and its neighbourhood. The findings also reveal various perceptions important to the significance of heritage, such as support from the local community and the issue of authenticity. Conflicts probably surface when various stakeholders pursue differing goals, e.g. the opposition of using heritage as a vehicle for economic development. The research implications of the study provide suggestions for future improvement in the development of group heritage cultural tourism. Moreover, in interpreting the findings, it is reminded that each cultural heritage project has its own complex attributes, e.g., economic, historic, social, emotional, physical, etc. Every destination is different, so is the complex history of each potential cultural heritage site, yet common themes exist.

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Effect of Stakeholders' Practices on Seismic Risk Mitigation Decisions

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Abstract

Promoting and enhancing property owners decisions to adopt seismic risk mitigation decisions such as strengthening of vulnerable buildings and insurance purchase to reduce the impact of seismic disasters is a major challenge in many earthquake-prone regions. Recent damaging earthquakes have demonstrated the need to reduce the risks in buildings having insufficient seismic capacity. These buildings are built, owned and inhabited by owners who make a range of decisions and choices that shape their level of vulnerability to earthquake disasters. Previous research studies found that many owners of earthquake-prone buildings are unwilling to adopt adequate seismic risk mitigation adjustments. The objective of this research is to investigate how property market stakeholder practices affect building owners' decision to adopt adequate mitigation measures.

The multiple case studies approach adopted provided new insights on how property market stakeholder practices such as non-assessment of seismic risks in property valuation, high earthquake insurance premiums and deductibles, and lack of trust in risk management professionals impede building owners' risk mitigation decisions. These research findings reveal that mandatory disclosure of seismic risks in all property market transactions could bridge the gap that exists between the disparate stakeholder practices. Mandatory disclosure of seismic risk could lead to improved seismic risks awareness and knowledge among the stakeholders. A collaborative approach between the stakeholders involved in property investment and seismic adjustment decisions also emerged from the research findings as a significant pathway to foster appropriate rehabilitation of earthquake risk mitigation.

Keywords: Property market, Seismic mitigation decision; earthquake-prone buildings (EPBs), Property owners

1. Introduction

Implementing seismic risk mitigation is a major challenge in many earthquake-prone regions. Given the infrequent nature and severity of earthquakes, seismic retrofitting of earthquake-prone buildings (EPBs) is essential to sustain community resilience. Many communities within active seismic zones have placed much emphasis on understanding the scientific nature of earthquakes, developing technical solutions and devising legislative means to ensure that EPBs are seismically retrofitted to reduce earthquake losses, but these efforts have not always resulted in satisfactory success. Seismic rehabilitation of EPBs lags behind advances in scientific and engineering understanding because little attention has been focussed on how to motivate building owners' decisions to adopt seismic adjustments (Hopkins et al., 2006). Property owners were found to be unwilling to retrofit their EPBs. This unwillingness has been a critical obstacle to earthquake pre-disaster planning and management, and has been attributed to many factors such as retrofit cost, risk perception and efficacy of mitigation measures which interact to influence mitigation decisions.

Studies in the social, economic and decision-making sciences have sought to address this dilemma from different perspectives. Many psychologists have focused on the impact of risk perception on mitigation decisions, concluding that how people perceive and personalise earthquake risks significantly influences the type of protective decision and behaviour adopted (Lindell and Prater, 2002). Similarly, various studies on earthquake risks and property market prices found correlations between risk information and communication style, property values, location, government-initiated policies and programmes, investment decisions and owners' attitudes towards adopting seismic adjustments (Onder et al., 2004, Egbelakin et al., 2011b). Despite the increasing number of studies, there is comparatively little research on how practices among the stakeholders in the property market affect a building owner's decision to adopt seismic risk mitigation measures.

2. Seismic Risk Mitigation in New Zealand

New Zealand is a located in a highly susceptible earthquake region. The recent earthquake events in September 2010 and February 2011 in New Zealand, coupled with a swarm of aftershocks, resulted in an estimated financial loss of $20 billion (Vervaeck and Daniell, 2011). The economic implication of these earthquakes suggests the need to develop other measures to reduce earthquake impacts. Seismic retrofitting of existing EPBs is one of the means of reducing losses in an earthquake event. The New Zealand Building Act (2004) was devised to reduce the level of earthquake risk to the public over time, targeting the most vulnerable seismic risk buildings. The enactment of the Act has several implications that affect seismic retrofit implementation. The Act allows Territorial Authorities (TAs) to choose either a passive or an active mitigation approach to implementing the policy. The active approach involves a rigorous identification and detailed assessment of EPBs and the retrofitting of the identified EPBs within three to ten years, while in the passive approach, seismic strengthening is triggered only by the application for a building alteration, change of use and life extension. A total of 45% of the TAs adopt a passive approach, 32% choose an active approach, while 23% choose the passive-active approach (DHB, 2005). One outcome of such a model, evident from the TAs mitigation approach, is that some districts and communities have good programmes in place to mitigate earthquake hazards, while other communities have done little or lack adequate resources to implement mitigation measures. The TAs were advised in the Act to undertake an Initial Evaluation Procedure (IEP) to identify EPBs within their jurisdictions. Steven and Wheeler (2008) reported that in the IEP carried out by a high seismic risk city (Wellington), 65% of the identified potential EPBs owners did not respond to the notices issued to them, while 43% of EPBs owners who responded requested time extensions ranging from 15 years to 25 years to seismically retrofit their EPBs. This low response from EPBs owners indicates they are reluctant to make decisions to implement risk mitigation measures. The subsequent section examines different property market stakeholders' practices and how they potentially influence building owners' risk mitigation decisions.

3. Stakeholders involved in Property Market Investment and Seismic Risk Mitigation Decisions

Seismic retrofit implementation involves making decisions to reduce the built environment's earthquake vulnerability (EERI, 1998), while property investment decisions are based on ensuring that an investor achieves a satisfactory return on his investments in the market place in form of an income flow, capital gain or a combination of both (Adair et al., 1994). Arguably, when an EPB involved, the same stakeholders are involved in both decision-making processes. These stakeholders include property owners, investors, developers, occupiers, valuers, insurers, lenders, government officials and hazard-related professionals contributing to property investment decisions (Luke et al., 2010). These stakeholders operate at different levels within the public and private sectors, and have varying impacts on building owner's risk mitigation decisions (Lindell et al., 1997). The different characteristics of these stakeholders in relation to seismic risk mitigation are discussed below.

Among these stakeholders, the property owner is the main seismic risk bearer, who makes decisions and undertakes actions that may affect a building's earthquake risk vulnerability and mitigation. For instance, an owner or investor makes choices between whether or not to purchase or invest in properties located in low or high hazard-prone regions. The owner also makes decisions about whether pre-disaster mitigation activities will be adopted to reduce the risks posed by earthquakes. Conversely, most building occupiers are generally unaware of a property's seismic risks, unless when issues regarding the building safety are raised (Butcher and Cooper, 2004, Egbelakin et al., 2011a). They are more interested in the building's end-use, and especially in matters affecting business productivity and operating costs. The real estate developer usually maximises profits by making an initial allocation of resources to increase economic activity in a location that is susceptible to earthquake hazard, but may not invest in any long-term seismic adjustments, since the property ownership will be transferred soon. Governing agencies such as local councils and Territorial Authorities (TAs) are important in seismic risk mitigation decisions because they are the level of government directly affected by a disaster and most capable of affecting property and business owners' decisions to adopt seismic adjustments through policies and regulation (Lindell et al., 1997). Insurance and financial institutions work together to ensure the sustainability of business transactions in the property market. A valuer's knowledge regarding a building's seismic risks can affect a property's market valuation analysis via an increase or decrease in the property value. Losses from natural disasters can have severe impacts on an insurer's financial situation, resulting in higher premiums for vulnerable buildings. Financial institutions have a significant stake in a catastrophic event, especially to the degree that a substantial portion of their financial assets are at risk from a single earthquake disaster (Lindell et al., 1997).

The prevalence of similar stakeholders in property investment and seismic risk mitigation decisions suggests similarities and overlaps in both decision-making processes, such as making investment and retrofit decisions simultaneously at the time of purchase or rehabilitation. These similarities could be employed to foster improved seismic risk mitigation decisions. Moreover, Langston *et al.* (2008) highlight the need for a transformation in the traditional decision-making processes of property stakeholders towards more sustainable practices, strategies and outcomes. Therefore, it is necessary to examine methods and strategies in the context of which property market stakeholders' practices will increase the likelihood of building owners voluntarily adopting adequate seismic risk mitigation measures.

4. Research Method

The objective of this study is to investigate the impact of property market stakeholder practices on building owners' earthquake risk mitigation decisions. A multiple case study research approach was adopted and interviews chosen as the method of data collection. Cases and participants were selected through a purposeful sampling procedure based on the research objectives, which are limited to the study populations. Thirty-five interviews were conducted in four geographic regions chosen using a risk-based selection method, utilising criteria such as seismicity, hazard factor and percentage of retrofitted and non-retrofitted EPBs. Four of the fifteen cities in New Zealand selected for the study showed diversity in seismicity, mitigation efforts, past earthquake events, economic resources and population (Statistics New Zealand, 2010). The stakeholders selected for the research included building owners, property valuers, engineers and architects, managers of insurance, financial and governmental organisations that have been involved in the seismic rehabilitation of EPBs. Building owners include persons that have and have not retrofitted their EPBs, while other participants have a minimum of at least two years recent involvement in EPBs retrofit projects. In examining the impact of market stakeholders' practices on building owners' retrofit decisions, the main questions explored were as follows:

- What roles do the stakeholders involved in investment and seismic risk mitigation decisions play in earthquake risk mitigation?
- How will the interrelationships among the stakeholders' practices enhance seismic risk mitigation?

In order to analyse the data collected, the recorded interviews were transcribed. All interview transcriptions were analysed thematically for qualitative content, using NVIVO software. A majority of participants are in the senior management category. 45% of the participants are building owners, while 55% are other stakeholders involved in seismic retrofit decisions. Three types of owners were identified: private (53.3%), public (26.7%) and non-profit (20%). 42% of the participants have personally experienced an earthquake. The average working experience of the participants in seismic retrofit building projects is 5.5 years, with a minimum and maximum of three years and eight years respectively. The average of 5.5 years of experience indicates that most respondents have reasonable experience in seismic retrofitting of EPBs.

5. Stakeholders' Practices and Interrelationships

The property investment landscape as a whole has gained considerable attention in moderating the market value of a building but little emphasis has been placed on understanding its full impact on seismic risk mitigation decisions. The stakeholders involved in property investment and seismic retrofit decision-making processes were examined in this study to understand how practices in the investment market affect building owners' risk mitigation decisions. The impacts of the stakeholders' roles and interrelationships on the property market of seismic risk mitigation decisions are discussed from the perspective of the various stakeholders.

5.1 Role of Property Owners

The motive for acquisition plays an important role in seismic risk mitigation decisions of EPBs. The interview findings revealed that most medium-scale owners, such as developers and property investors, who buy an existing structure are likely to own it for at most, a few years before selling it. Developers' short–term investment perspective does not encourage seismic retrofit decisions. 88% of the owners interviewed argued that developers typically do not engage in seismic rehabilitation of EPBs. Earthquake risks are usually transferred to future owners because the buildings are viewed as short-term investments. One of the property owner-developer's interviewed mentioned that,

"My investment in a particular building depends on what I want to do with the building. I may be interested in land value, redevelopment or renovate and sell. If I am renovating, it's usually to the minimum code requirement".

67% of the participants mentioned that most developers acquire older buildings for anticipated demolition and future redevelopment, with these buildings usually demolished and their sites used temporarily as car parks. Consequently, the heritage characteristics of these older buildings, which generate revenue in terms of tourism, are usually lost because of the owners' motive of acquisition. Hence, the motive for acquiring some older commercial buildings could impede the adoption of adequate earthquake risk mitigation decisions.

5.2 Role of Property Valuers

A pertinent issue revealed in this study involves the part played by property valuers in the assessments of property values of retrofitted and non-retrofitted EPBs. The interviews revealed that earthquake risk receives only a marginal consideration in current investment practices and property valuation in

New Zealand. Given that earthquake risk appears to have potential significant effect on the overall income return from a property and hence on the building's market value (Onder et al., 2004), seismic risk is poorly accounted for in property valuation and investment decisions. 68% of the property valuers interviewed explained that seismic risks are generally not considered in property valuation reports, unless specifically requested by clients. One of the stakeholders interviewed said,

"Most times when making real-estate investment decisions, we assume that risks from rare disaster events such as earthquakes are negligible compared to other market risks relating to the building's net operating income and taxation".

This assertion suggests that seismic risks are not generally considered in the financial analysis of most investment opportunities, because earthquake risks are not considered significantly in property valuation assessment. As a result, potential investors are not well informed of the financial implication of the property's seismic risks, strengthening requirements and associated costs of retrofitting. Therefore, insufficient weighting is accorded to potential earthquake strengthening costs in investment and purchase decisions. This insufficient weighting thus renders retrofitting of such EPBs less viable in the market. There is the possibility that if property valuation directly assesses the economic implication of seismic risks in property valuation, investors could adequately estimate the cost of retrofitting such an EPB and factor it in investment decisions.

5.3 Role of Design Consultants (Engineers)

Engineering professionals have had considerable input into policy development in relation to seismic retrofitting of EPBs. Professionals in the earthquake engineering industry possess substantial information and knowledge regarding the likelihood of an earthquake event and its potential impact on the built environment. Evidence from this study shows that although engineers are knowledgeable about the technical solutions recommend for seismic retrofitting of EPBs, building owners do not believe in the effectiveness of the recommended retrofit solutions, leading to lack of trust in the professionals. The interviews revealed that property owners' trust in hazard management professionals such as engineers have significant influence on their risk mitigation decisions. One of the building owners declared that,

"I don't believe any of the solutions recommended to me by these engineers. You see that building over there; when I wanted to rehabilitate it, one engineer recommended 33%, while another 67%NBS. Do you think they know what they are doing? I have decided not to do anything about it for now, since the last Gisborne and Christchurch earthquakes, where my friends' retrofitted buildings were damaged"

58% of the owners consulted neither believe in the effectiveness of the engineer's design solutions nor think that the engineer is capable of providing functional retrofit designs. Participants' belief in the efficacy of seismic retrofit design solutions differs between the cases. For instance, in case one, 52% of the participants indicated that they do not believe in the seismic retrofit techniques available in New Zealand. Insights from the interviews suggested that the differences in the responses to questions regarding trust and belief in seismic retrofit techniques and professionals across the cases, relate to damage to new buildings by the recent earthquake events. Damage to new buildings with supposedly high seismic strength affects building owners' perception of the design engineers and the efficacy of the structural solutions recommended. The study further discovered that disparate opinions among consulting engineers in New Zealand contributed to the lack of trust in seismic retrofit professionals. Engineers do not have a consensus on the appropriate seismic performance standard that should be adopted when recommending technical solutions for retrofitting to property owners. Most owners become confused when two engineers recommend strengthening levels that differ widely; this is interpreted as incompetence.

5.4 Role of Regulators

The regulators have significant impacts on property industry and building owners' decisions to mitigate seismic risks. These regulators include City/Territorial local councils, Department of Building and Housing (DBH) and industry group organisations. They are responsible for formulating, implementing and offering recommendations on the regulations guiding seismic risk mitigation. A significant impact of these regulations on seismic risk mitigation decisions relates to the non-mandatory disclosure of a property's seismic risk at the point of sale or lease. The interviews revealed that most of the stakeholders in the market have little or no knowledge about seismic retrofit standards, legal obligations and potential liabilities relating to seismic risks, suggesting that non-mandatory disclosure of buildings' seismic risks in earthquake-prone building policies contributes to this lack of awareness. Similarly, 79% of the participants were unaware of the obligations imposed by changes in the Building Act (2004) regarding EPBs. A lack of awareness of the building codes and legislation undermines the adoption of risk mitigation measures by owners of EPBs. One of the participants said that,

"It is difficult for all market stakeholders to know and understand the issues around seismic risks unless the law mandates that it must be disclosed. Most owners and real estate agents prefer to be silent on such issues because it will affect their business transactions"

Presently, there is no incentive for seismic risk disclosure at the point of sale or lease of a building in the New Zealand market. Of the participants interviewed, 63% believed that mandatory disclosure of a property's seismic risk at the point of sale or lease, and exhibiting placards on building to warn people about the property's seismic risk, would increase market awareness on seismic risk issues and perhaps force down the value of non-retrofitted EPBs. Mandatory disclosure of seismic risks could therefore affect reconstruction and sale transactions of EPBs buildings and be significant drivers of enhanced seismic retrofit and investment decisions. Mandatory disclosure of seismic risks in earthquake policy would provide accurate information to the buyer, insurer and lending institution. All parties involved would understand the risk level in the building before completing a business transaction. However, 77% of the building owners and developers claimed that mandatory disclosure of risk would slow down the time taken to complete the property sale or rental transaction. They added that mandatory disclosure of risk in EPBs assessment would increase the economic burden on building owners without allowing a gradual cost adjustment. Thus, a further examination on how mandatory seismic risk disclosure affects earthquake hazard mitigation is essential.

5.5 Role of Earthquake Risk Insurance Providers

High earthquake insurance premiums were identified in this study as one of the factors that affect building owners' seismic risk mitigation decisions. Earthquake insurance policies in New Zealand generally cover a portion of shake damage to a structure from a seismic event. Building owners may also need to spend money for rehabilitation in an earthquake event for damages not covered under the policy. Across all cases studied, the participants indicated that the cost of earthquake insurance is relatively high in New Zealand. One of the building owners explained that,

"It was difficult for me to get insurance for this building and I have to pay a huge amount of money for insurance premiums. The guy from the insurance company told me even if I retrofit my building to a higher performance level, the insurance premium is not likely to change".

A large proportion of the participants (86%) agreed with the above assertion above that owners of EPBs often find it difficult to purchase earthquake insurance and in most cases pay very high premiums. This assertion confirms the practice among insurance providers of either increasing premiums or limiting coverage in high risk zones in order to reduce insolvency risk. High earthquake insurance premiums increase the operating expenses of older buildings, which are usually earthquake-prone compared with newer properties, making them less competitive in the market, thus becoming an impediment to the owners' seismic risk mitigation actions.

In addition, evidence from the findings shows the cost of insurance premiums does not reflect seismic mitigation actions implemented in an EPB. Of concern was that 28% of owners interviewed complained they were unable to purchase insurance after retrofitting their EPBs to a structural performance standard greater than 67% NBS. Though EERI (1998) suggested that insurance premiums should reflect risk and take into account mitigation actions on the building, provided the insurance losses on the structure are reduced by implementing such action. This is not yet the case in New Zealand. Participants from the insurance industry claimed that accessing individual seismic mitigation actions on EPBs is difficult and costly. Moreover, the lack of a reliable database hampers the assessment of the mitigation actions undertaken. A total of 92% of the interviewees suggested that buildings retrofitted well beyond minimum requirements should be eligible for premium discounts, indicating that reduction in insurance premiums is a key component of any hazard mitigation program aimed at improving seismic retrofit decisions and implementation of EPBs. This study finding shows that reducing insurance premiums for those undertaking seismic hazard mitigation would encourage owners to make decisions regarding adopting risk reduction measures. Moreover, insurance premiums that reflect a building's seismic risk would provide earthquake hazard signals to individual owners.

5.6 Role of Financial Industry

High interest rates on loans were identified in this study as one of the factors that affect building owners' mitigation decisions. The study showed that banks are often less eager to lend to owners of older buildings unless the owners have built up enough equity to support the loan. Hence, most small-scale owners of EPBs often find it difficult to secure loans to retrofit their EPBs. Even when these owners are able to secure loans for retrofitting, it comes with high interest rates, leading to a high operating cost for the building. One of the owners explained that financial institutions usually request a full replacement earthquake insurance cover before approving the desired mortgage to purchase a potential EPB. However, most insurers are unwilling to insure such buildings. Therefore, potential owners are discouraged from the purchase and retrofit of an EPB. Hence, financial institutions in New Zealand play a minimal role in promoting seismic risk mitigation decisions or implementation. Lenders and insurers to date have contributed to a situation in which earthquake risk is not managed equitably in the market place (Earthquake Engineering Research Institute, 2000). The government now bears a significant portion of the risk by paying for response-rescue activities, clean-up and recovery costs in an earthquake event. Erdik and Durukal (2008) suggest that financial organisations should participate in comprehensive urban regeneration projects aimed at reducing earthquake vulnerability within the built environment, by providing long-term low interest loans to building owners to implement risk reduction measures.

6. Discussion

The findings of this study provide empirical support regarding the impacts of stakeholders' practices and interrelationships on building owners' earthquake risk mitigation decisions. The findings reveal the complexity of seismic risk mitigation decision-making, which arises from the wide range of stakeholders involved, who differ in their knowledge, resources, and perception of earthquake risks. Property owners' eventual risk mitigation decisions are often dependent on the involvement and recommendations of other stakeholders involved in the decision-making process, and those who have vested interests and benefit from such decision outcomes. A significant intervention emerging from this study that could reduce the complexity of decision-making and improve stakeholder practices enhance the implementation of earthquake risk mitigation measures, relates to mandatory disclosure of a property's seismic risks. Mandatory disclosure of seismic risks during the lease or sale period would allow accurate information to be communicated to buyer, insurer and lenders, leading to an informed market. Insights from the interviews suggested that a market that is adequately informed about earthquake risks and mitigation benefits would enhance decisions to retrofit EPBs, as valuers will be obligated to estimate the cost of a building's earthquake risk for other market stakeholders. Property owners would recognise that their property value could reduce if their seismic risk became public information, thus promoting the adoption of seismic adjustments. Subsequently investors, owners and insurers could accurately assess the cost of the retrofit required, and factor it into property prices and investment decisions. The insurer would adequately estimate the building risk through a risk-based premium, reducing the capitalisation rates of retrofitted buildings due to lower investment risk.

To explore the use of mandatory disclosure of earthquake risks in property market transactions and among stakeholders, a balanced awareness program regarding seismic risk and retrofit benefits tailored, to meet the demands of all stakeholders in the property market, is necessary. This programme would help owners, investors, insurers, lenders and occupiers to make sound investment decisions and improve the practices of other professionals in the market who deal with earthquake risks. In addition, appropriate risk definition and effective communication plans, such as including a mix of passive and proactive approaches that utilise both traditional and emerging information technologies, are important vehicles to ensure the market stakeholders and implementers understand the need for and benefits of adopting seismic adjustments, so that increasing seismic risk awareness can have a meaningful impact. Increasing seismic risk awareness in the property market by using adequate risk definitions and communication principles has the advantage of simultaneously improving people's perceptions regarding earthquake probability and severity (Egbelakin et al., 2011a).

7. Conclusion

The objective of this study is to examine the impacts of property market stakeholders' practices on building owners, seismic risk mitigation decisions. Significant impacts of the property investment market on risk mitigation decisions identified in this study include: the non-assessment of seismic risks in property valuations, high earthquake insurance premiums and deductibles and lack of trust in risk management professionals. One way to overcome the impact of these disparate stakeholders' practices on earthquake risk mitigation decisions relates to mandatory disclosure of seismic risks by relevant regulatory frameworks in all property market transactions. If adequate strategies considering these factors are developed or nurtured, the market place could ultimately improve many EPBs within the community. Society in general would greatly benefit from a seismic retrofit awareness campaign aimed at reducing the physical, social, and consequential societal losses that will eventually be covered by the public. It is important to note that the above factors concern various stakeholders involved in seismic retrofit decisions and their implementation, suggesting a means by which insurance companies, financial institutions, building owners and professionals in building and real estate communities can work together to foster seismic rehabilitation of vulnerable buildings.

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Raising Awareness on contractual risk allocation

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Abstract

In the construction industry, contractual risk sharing is often associated with informal partnering approaches, having no formal monetary consequences and a suspect legal dimension. Following a process-orientated classification of risk sharing within commonly used risk management systems, the paper at hand outlines the status quo within risk sharing experiences, which most often is based on diffuse parameters. The differentiation between the notions of "risk" and "uncertainty" within the decision theory and the classical probability theory is used to demonstrate the major problem of using simple risk formulas by means of an impressive example from off-shore oil drilling. If the consequences of specific damages are established and evaluated (e.g. having huge dimensions), the contractor and client still have to face the problem of a frequency- versus a classical probability-calculation. In case of extremely low probabilities, the monetary consequences of an incident seem to become infinitesimal, thus negligible. The example shows the major implications for a construction project. Risk sharing principles are discussed and fundamental terms of decision theory – such as preferences, utility, certainty equivalent and risk premium – are introduced to define risk attitudes of contractors and clients through risk-utility functions. Using the Bernoulli-principle within a simple coin flipping game provides access to a specific risk sharing example, illustrating contractual risk sharing between client and contractor on the basis of risk-utility attitudes.

Keywords: risk allocation, risk utility, decision theory

1. Introduction

The authors face the challenge of classifying the term *risk sharing* - which is most frequently misused in literature – not with regard to the beaten track of partnering approaches, mostly considering informal regulations. The following remarks do not raise a philosophical claim or a moral intention to somehow attain *"tender or affectionate cooperation"* on construction sites. Instead, we want to demonstrate how fair and reasonable risk allocation can be made accessible by means of a calculative approach using decision theory and risk-utility functions of the contractual parties.

2. Classification of Risk Sharing within RMS

Ideally, we decide on matters of risk sharing within the framework of Risk Management Systems (RMS). Within those systems, different processes do exist which are not consistently regulated. A huge number of RMS is available to provide a framework for the process of risk sharing. This paper uses the reference model of Wiggert (2009) which defines five base modules within RMS:

1. Initiation of RMS (decision on purpose and scope)
2. Risk identification
3. Risk analysis and evaluation
4. Risk management
5. Controlling

The process of risk sharing follows step number three, in which comprehensive fundamentals for decisions concerning the taking over of risks, are developed. Here, we point out that risks at this step have already been assessed and evaluated with respect to their probability of occurrence and their extent of damage. Step four therefore simply clarifies the question of alternatives regarding conscious acceptance of risk or a full or partial risk transfer to the contractual partner. Due to strategic perceptions, decision makers must always decide between a certain and an uncertain situation.

2.1 Status Quo – Strategic Fee

When deciding upon risk sharing, the decision maker (client or contractor) must always weigh up effort and benefit (utility) through an evaluation of risk transfer costs. Far too often, these questions are treated with the determination of so-called "strategic fees," which, in the end, are based upon gut instincts. In the best case scenario, these instincts are founded on experience and know-how but still are not objectively comprehensible and verifiable. This paper introduces a new approach founded on the rational behavior of contractual partners.

2.2 Methodology and Purpose

Our approach is based upon the practical-normative decision theory, which is commonly used in business sciences. By applying Risk-Utility Functions (RUF) – representing Risk-Utility expectations of both individuals and organizations – questions of risk sharing are dealt with rationally and definite monetary consequences are derived. The main objective is to calculate specific risk transfer costs, which reflect the risk biases of client and contractor. Further applications are outlined in the outlook at the end of the paper.

3. Risk Definition

While the German term "*Risiko*" generates 77,000,000 hits for a simple Google search, the English term "risk" yields 1,020,000,000 hits, showing that the issue of risk seems to be relevant and important. Risk literature is elusive, thus summarizing writings is helpful. Concerning this matter, we refer to the thesis of Wiggert (2009), who listed 69 risk definitions from literature and another 61 definitions from standards and rulebooks. The authors adopt the definition of the term "risk" as developed by Wiggert:*"Risk is the influence of uncertainty upon performance, ensuing from consciously or unconsciously set goals. A potential increase of relative performance is called chance and a potential decrease is called venture (German term: Wagnis)."* Of crucial importance within this definition is the inclusion of the term "chance," as the technical implementation through probability and extent of damage has already been adopted in the ONR 49000:*"A combination of probability and extent of damage. Risk includes chance and damage potential. It estimates the scenario due to its probability and its consequences. Not only sudden incidents are included, also unexpected damages as well as sneakingly eventuating incidents."* Formally we write R = EW x AW. Risk (R) is the product of probability of occurrence (EW) and extent of damage/consequences (AW). According to the terms of decision theory, we generally have to differentiate between decisions under risk and decisions under uncertainty. While decisions under risk imply the knowledge of both probability of occurrence as well as the extent of damage, we only become aware of the extent of damage if we make decisions under uncertainty.

4. The Probability Problem

It seems almost too simple to be suitable for practical implementation when a specific construction project is available and contractual agreements are to be developed. While potential implications of damages are identified relatively easily, it seems to become extremely difficult to quantify the probabilities of the incidents. Probability perception at that level is of vital importance. One has to differentiate between classical probability and statistical frequency:

1. Laplace`s probability: defines the classical approach which determines probability as the ratio of favorable to possible incidents.
2. Probability based on the results of frequency: relative frequency of a random event is approaching probability if the experiment is repeated often.

What do the authors hope to illustrate with those two perceptions? In contrast to insurance companies, which are able to calculate their premiums considering a huge pool of random events, a company in the construction industry (e.g. contractor) is only dependant on one experiment – its construction project. For that reason, the risk premiums of contractors would have to be much higher than with common business strategy. Mechanisms of the market, as well as common tender procedures, often make it difficult to be aware of risks – on both sides of the contract. A conscious transfer of risk at the end is no longer achieved for that reason.

4.1 Example

To put the aforementioned problem into real numbers, we will provide a very impressive example from offshore oil drilling. We will demonstrate a simple risk calculation. What happened? On April 20th, 2010, the exploration oil platform "deepwater horizon" exploded, attributable to a dysfunctional safety device and other reasons which still remain a mystery. 11 people lost their lives and the escaping oil caused the most detrimental environmental disaster to date in the history of the U.S. Currently, the British oil company BP is going to court against former partner company Halliburton, claiming 20 billion dollars as compensation for damages. Halliburton was declared responsible for sealing the borehole.

Using this example, we will pose the following two questions:

1. Would it have been possible for Halliburton to calculate/estimate such risks in advance?
2. What amount would result from such a vague estimation?

facts:	1979 – 2000:	5 oil platform disasters worldwide[1]
	1980 – 2003:	10 registered blowouts[2] in North Sea & Gulf of Mexico[3]
	2005 – 2010:	18,000 offshore drillings worldwide[4]
assumptions:		50% of disasters caused by blowouts[5]
		extent of damage € 7.5 billion euros6
a simple risk estimation could be obtained as follows:		
		R = EW x AW leads to: = 6.7x10-5 x 7.5 billion euros R = 500,000 euros

Therefore, the contractor would have been able to calculate the risk of a possible disaster in a very simplified way. Regarding the calculated extent of damage, we note the following: The total expenditure for the deepwater horizon exploration project, as foreseen in the budget of BP, reached 74 billion euros. If the probability of occurrence is considered in the estimation, we calculate the risk to be 500,000 euros, which is not even a 7th thousandth part of BP's total planned costs. Although Halliburton's customer base includes almost the entire oil industry, they would need to set up 15,000

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[1] http:/www.zeit.de/wissen/umwelt/2010-04/oelpest-bohrinsel-hintergrund, Unfälle auf Bohrinseln sind keine Seltenheit, accessed on 03.01.2012, 13:15

[2] Term from deep drilling business: „*Uncontrolled outflow of drilling mud, oil and(or gas out of the drilling hole. Often oil and gas inflames thereby*, http://de.wikipedia.org/wiki/Blowout_%28Tiefbohrtechnik%29, accessed on 04.01.2012, 14:00

[3] http:/www.zeit.de/wissen/umwelt/2010-04/oelpest-bohrinsel-hintergrund, Unfälle auf Bohrinseln sind keine Seltenheit, 1. Mai 2010, accessed on 03.01.2012, 13:15

[4] http://about.datamonitor.com/media/archives/3803, Global offshore drilling fully recovered by 2011, 1. März 2010, accessed am 04.01.2012, 11:15

[5] Simplifications by the authors derived from 1 and 3.

[6] Assumption of the extent of damage made by the authors. Deepwater Horizon thereby defines the upper boundary, actual disasters like the accident of Chevron ahead of Brasilia's coast provide further estimates.

successful projects on the scale of the deepwater drillings. The established values are therefore quite simple to calculate but provide no adequate basis for a transparent and fair risk allocation. How would a technical approach be possible but yet provide an adequate basis for contracts and tenders? It should at least be possible to provide a rational reference point for negotiations. After clarifying further necessary terms, we will bend the bow from initially abstract risk biases to mathematically founded risk-transfer costs.

5. Preferences and expected Utility

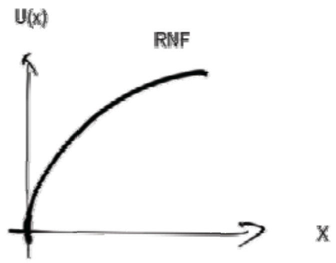
As mentioned previously, the willingness of the parties to take on risks is the deciding factor when considering possible risk sharing. This willingness is influenced by the *preferences* of the person or organization which is entitled to make the decisions. The term *utility* is now introduced as an expression of those preferences, highlighting the advantages of a chosen alternative compared to certain actions. Regarding risk sharing problems, the preferences define the utility of the parties, derived from either a risk take-over or a risk transfer. Due to the fact that all these decisions are based upon probabilistic data, the term *expected utility* is introduced. Within the concept of decision theory, we endeavor to make rational choices when deciding upon uncertainty. Rational choices constitute the choices which optimally reflect the decision maker`s preferences.

5.1 Bernoulli - Principle and Risk Attitude

In the normative decision theory, there are several criteria which endeavor to model the preferences of decision makers mathematically. Most of them are based on mathematical expectation (expectancy value). An extraordinary position within those principles is possessed by the Bernoulli principle. Decisions in accordance with this principle are not only based on mathematical expectation, but also on the expected value of the resulting utility (Expected Utility). Bernoulli's decisions are therefore derived in two steps:

1. Determination of the utility function (representing the preferences of the decision maker)
2. Choice of the alternative, for which the value of the expected utility is higher.

The utility function is used to describe the risk attitude of the decision maker. In literature, these functions are therefore called Risk-Utility Functions (RUF). The relationship between utility and risk is shown in Figure 1 displayed below.



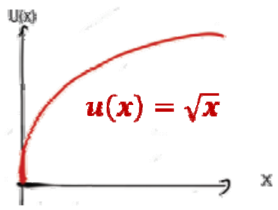
U(x)…expected value of the decision maker (ordinate)

x…necessary input of capital (Assets) (abscissa)

Figure 1: Risk-Utility Function

The relationship indicated between risk and utility could be described by means of an infinite number of equations/functions. Commonly exponential or logarithmic functions are used, most frequently square and root functions. To describe risk attitudes mathematically, we use three main categories of risk-utility functions:

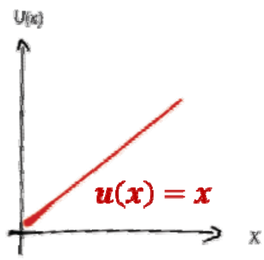
5.1.1 Risk aversion



Parties show a risk-averse attitude while expecting relatively lower returns at higher input levels. The expected marginal utility falls as the input of assets increases. The risk-averse party is willing to guarantee the risk paying transfer costs for a safe and certain situation. Risk functions of risk-averse parties are always concave functions, as shown in *Figure 2.*

Figure 2: *Root function as a typical risk-averse RUF.*

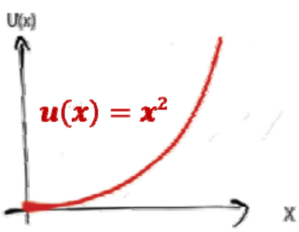
5.1.2 Risk neutrality



The probability of chance and venture is estimated equally, when risk attitude is risk-neutral. The expected value of utility is rising proportionally with the input of assets. This attitude is represented by a linear RUF.

Figure 3: Linear function as a typical risk-neutral RUF.

5.1.3 Risk preference



If a contractual party is willing to consciously take on risks, we call this attitude risk-preferring. The more input (assets) are invested, the more utility is expected. The function rises over proportionally, represented by a convex RUF.

Figure 4: Convex square function as a typical risk-preferring RUF.

5.1.4 Certainty Equivalent and Risk Premium

To introduce the two terms, an example is presented from Besanko, Dranove et al, 2010:

The freshly minted MBA: A freshly minted MBA gets two identical job opportunities, differing only in payment. At job 1, the employer offers a fixed payment of $ 100,000 at the end of the first year of employment. At job 2, the employer offers to play a coin flipping game at the end of the first year, paying $ 40,000, should the coin land heads-up and $ 160,000 if the coin lands tails-up.

Most people - when presented with a choice like this - would prefer the certain payment of $ 100,000, representing the expected value of the game. It means that most people show a risk-averse attitude. The question is now, what would happen, if the employer of job 1 reduces his fixed payment offer step by step? It has been empirically proven that most people start thinking about playing the game at a fixed payment of $ 80,000. This indifference point is called certainty equivalent, representing the safe amount of money/assets which equates to the expected value of the uncertain choice. The difference between the mathematical expected value and the certainty equivalent (CE) is called risk premium (RP, in our case $ 20,000). Formally we write:

$$\boldsymbol{RP = E(x) - CE}$$

with: *RP*...risk premium

$E_{(x)}$...expected value of uncertain assets

CE...certainty equivalent

The mathematical expected value of uncertain assets ($E_{(x)}$) is determined by the Risk Utility Function (RUF). The individual RUF represents the risk attitude of the decision maker. According to the above-mentioned categories, risk-averse, risk-neutral and risk-preferring decision makers could be described by $E_{(x)}$ > CE (risk aversion), $E_{(x)}$ = CE (risk neutrality) and $E_{(x)}$ < CE (risk preference).$\boldsymbol{E(x) > CEE(x) = CEE(x) < CE}$ The Bernoulli principle – used as a basis for this paper – incorporates the probability of risk to occur and equates it to the RUF of the deciders.

$$\mathbf{E(u(x)) = u(CE)}$$

with: $E(u_{(x)})$...expected utility value of uncertain assets

u(CE)...utility of certainty equivalent

When deciding according to this principle, the expected utility value of uncertain assets matches the expected utility value of the certainty equivalent. After discussing all the essential terms related to decision theory, we prepared a simple example to aid comprehension of the concluding example on risk sharing within the construction sector.

6. Coin flipping game

Player A and organizer B: using a pool of $ 1, a game is proposed to the player. If a coin lands "heads-up" the player wins $ 2. If the coin lands "tails-up" the player loses his pool of $ 1. How would player A decide according to their individual risk attitude (RUF)?

Expected value of payout according to the following formula:

$$\boldsymbol{E(x) = 0.5 \times 2,00 + 0.5 \times 0,00 = 1.00} \ \$$$

6.1 Risk-averse Player

If we assume a RUF according to the function $u(x) = \sqrt{x}$ **,** the risk-averse player would calculate their expected utility $E(u)_{(x)}$ as:

$$\mathbf{E(u(x)) = 0.5 \times \sqrt{2,00} + 0.5 \times \sqrt{0,00} = 0.71}$$

Using Bernoulli`s principle, for the CE, we obtain the following result:

$$\mathbf{E(u(x)) = u(CE)}$$
$$\mathbf{0.71 = \sqrt{CE}}$$
$$\mathbf{CE = 0.50}\ \$$$

The expected utility of 0.71 implies a justified pool of 0.5 $ for the risk-averse player, who will therefore not play the game with organizer B.

6.2 Risk-preferring Player

If we assume the risk-preferring player is represented by a RUF of $u(x) = x^2$, they would obtain an expected utility $E(u)_{(x)}$ of:

$$\mathbf{E(u(x)) = 0.5 \times 2,00^2 + 0.5 \times 0.00^2 = 2.00}$$

Using Bernoulli`s principle, the CE is as follows:

$$\mathbf{E(u(x)) = u(CE)}$$
$$\mathbf{2.00 = CE^2}$$
$$\mathbf{CE = \sqrt{2.00} = 1.41}\ \$$$

When expecting an individual abstract utility of 2.00, the risk-preferring player would play the game for definite, even if they were offered to claim a pool of $ 1.41 instead of $ 1.00.

6.3 Risk-neutral Player

For the risk-neutral player, the expected mathematical value of $ 1.00 equates to their expected utility. Possible gain or loss is weighted equally. As a consequence, the player is indifferent with regard to playing the game or non-attendance.

6.4 Interpretation

In the example shown, the advantages and disadvantages of playing and non-attendance are compared. Due to the personal risk attitude, the players evaluate the game situation in a different manner, resulting in differently justified pools. In the upcoming, concluding example, the gain/loss expectation is replaced by a risk sharing decision. The objective is to calculate rational risk transfer costs for a given RUF within a construction project.

7. Sharing ground conditions risk

A client possesses a project budget of $ 4 million for the construction of a deep excavation pit. Before contract signing, a specific soil risk concerning unknown ground conditions was identified and evaluated, indicating a possible extent of damage of $ 800,000.[7] Probability of occurrence should be 10%. Two possible asset scenarios could now occur for the client after the project is finished:

1. The client maintains the entire budget of $ 4 million (no damage case[8], with a probability of 9/10))

2. The client has to bear $ 800,000 of costs for treatment and disposal of contaminated soil which reduce his budget to $ 3,200,000 (with a probability of 1/10)

Mathematically-speaking, the client has to expect an asset situation of $ 3,920,000, representing the expected value of the uncertain situation.

$$\mathbf{E(x)} = {}^{\mathbf{9}}\!/_{\mathbf{10}} \times \mathbf{4.000.000} + {}^{\mathbf{1}}\!/_{\mathbf{10}} \times \mathbf{3.200.000} = \mathbf{3.920.000}\ \$$$

The client now wishes to fix a risk transfer with the foundation contractor as part of the contract. The objective for the client is a complete transfer of the possible damage of $ 800,000 to the contractor`s sphere. The crucial question is now: how much money would the client find appropriate for the risk transfer according to his/her risk attitude (expressed by a known RUF)?

7.1 Risk-averse Client

Using the same RUF as in the previous example, we use the formula $\mathbf{u(x)} = \sqrt{\mathbf{x}}$ to establish the client`s risk-averse attitude. To calculate the costs of risk transfer, we have to calculate the individual expected utility E(u(x)) and the certainty equivalent CE.

$$\mathbf{E\big(u(x)\big)} = {}^{\mathbf{9}}\!/_{\mathbf{10}} \times \sqrt{\mathbf{4.000.000}} + {}^{\mathbf{1}}\!/_{\mathbf{10}} \times \sqrt{\mathbf{3.200.000}} = \mathbf{1.979}$$

$$\mathbf{CE} = \mathbf{1.979^2} = \mathbf{3.916.441}\ \$$$

The risk-averse client therefore must expect an asset situation (wealth) of $ 3,916,441 after the project has been concluded. By subtracting this amount from the project budget of $ 4 million, we calculate a risk of $ 83,559.

$$\mathbf{4.000.000 - \ 3.916.441} = \mathbf{83.559}\ \$$$

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[7] As an example for unforeseeable ground conditions risk we assume a contamination, not investigated through ground investigation. The amount of $ 800,000 as well as the probability of occurrence are roughly estimated.

[8] Damage case: treatment/removal of contaminated soil. The authors assume that the specific risk on contaminated soil is of non-insurable type.

7.2 Risk-preferring Client

Risk preference could be represented by a RUF $\mathbf{u(x) = x^2}$ **,** which was used in the previous example. To calculate the costs of risk transfer, once again we must work out the individual expected utility $E(u_{(x)})$ and the certainty equivalent CE according to:

$$\mathbf{E(u(x)) = {}^{9}/_{10} \times 4.000.000^2 + {}^{1}/_{10} \times 3.200.000^2 = 1,5424 \times 10^{13}}$$

$$\boldsymbol{CE} = \mathbf{\sqrt{1.5424x10\text{^}13} = 3.927.340}\ \$$$

The risk-preferring client therefore must expect an asset situation (wealth) of \$ 3,927,340 after the project has finished. By subtracting this amount from the project budget of \$ 4 million, we calculate a risk of \$ 72,660.

$$\mathbf{4.000.000 - 3.927.340 = 72.660}\ \$$$

7.3 Interpretation

For transferring the risk on ground conditions to the sphere of the foundation contractor, the risk-averse client must pay at least \$ 83,559, whereas a risk-preferring client has to pay \$ 72,660 as maximum transfer costs. How can we now interpret these values, which at first glance seem abstract? According to the individual risk attitude, the deciders either evaluate risks above or below the mathematical expected value. Deviations from the mathematical expected value are expressed by the risk premium (RP) - having either a positive or negative sign - respectively certainty equivalent (CE). By assuming a contractor who is calculating analogously according to their specific RUF, a transparent risk allocation could be achieved in the contract. When a client is risk-averse and a contractor is risk-preferring (and RUF are known as assumed above), the parties could calculate their expected risks as either \$ 83,559 (client`s maximum risk transfer costs) or \$ 72,660 (contractors minimum fee to take over the risk). A possible equilibrium could be achieved by bargaining with open strategies: Both parties could benefit from a win situation when meeting at \$ 72,110, which represents the Pareto-optimum.

8. Summary and Outlook

This paper presents a method to calculate risk transfer costs, based on risk-utility attitudes within the concept of decision theory. By adopting several simplifications, it was demonstrated that with known Risk-Utility-Functions (RUF) and trivial probability distributions, a rational and impartially verifiable basis for risk sharing issues could be derived. The presented approach outlines the first step towards a theoretically-correct risk decision making tool, reducing commonly used subjective and vague speculations when having to decide upon possible risk transfers. One basic assumption in the context of this method is the presence of symmetric information between the contractual parties. Further investigations will endeavor to implement calculation methods based on the institutional economics sphere – such as Principal Agent models. The main features of the new approach are the Risk-Utility Functions, which are able to constitute a wide-ranging and important instrument for strategic business planning. Research on these functions for the construction industry is the current challenge for the authors.

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Common Sense Remedies for the Workers' Compensation Epidemic in the U.S.

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Abstract

When asked their goals, contractors interviewed as part of this research gave many answers, but the two most common could be stated: 1) Get work, and 2) Prosecute work. Workers' Compensation (WC) insurance is very important to the competitiveness and competence of a contractor and thus to the meeting of these goals. Lingering WC claims that cause injured workers to blame the contractor can reduce the efficiency of a contractor through employee distrust and disloyalty and also, through raising the contractor's modification rate, can financially damage contractors and make them less competitive. A workforce, made less loyal through a perception of a lack of care on the part of an employer can make it harder for contractors to prosecute work once they have procured it. Why do WC claims take so long to resolve in the U.S.? Why does it take so long for injured workers to receive their benefits? Why is there so much fraud in the system? Is there hope for improvement in the area of WC? This paper answers all these questions and more, while introducing and explaining new concepts in WC that most contractors have never heard of and sharing roadmaps to legislative change and to the establishment of programs that will help meet the challenge of today's WC dilemma.

Keywords: Workers' Compensation, Fraud, Negotiated Workers' Compensation, Insurance

1. Introduction

"Why are you a contractor?" "What are your goals as a contractor?" These two questions were asked of dozens of electrical contractors in nine US states as part of a research project funded by Electri 21, the research foundation of the National Electrical Contractors Association. The answers to the two questions numbered almost as many as there were respondents. The answer to the second question cuts to the heart of the purpose for this research, and hence, to the heart of this paper.

The most common responses to the second question can be stated as 1) Procure work, and 2) Prosecute the work. Workers' Compensation (WC) is inarguably tied to the contractor's ability to do both. The ability to procure work is also known as being competitive. The more consistently competitive a contractor is in the bidding of work, the more work he will procure. In the highly competitive environment of the low-bid system, where even the smallest edge is eagerly exploited by the contractor, a sizable advantage such as presented by lower WC premiums is much sought-after.

Conversely, higher WC premiums can doom a contractor's quest to procure the work needed for survival and prosperity. When a WC claim stays on the books of an insurance carrier (insurance provider, insurance company) for years, it works against the contractor each of those years by raising the contractor's experience modification rate. The Experience modification rate, aka "mod. rate" or "EMR," is an index number assigned by the insurance industry to an employer based on the number of open WC cases that employer has at any time, or over a designated time period. The insurance carriers use the EMR to set WC insurance premiums.

Many agencies and many private construction owners will not allow a contractor with an EMR of more than 1.00 to bid on their work. Of course, higher mod. rates mean higher premiums. The premiums paid by the vast majority of contractors, those using traditional state WC programs, are higher than those paid by those in new, innovative programs to start with. Since many of these programs have a proven track record of getting benefits to injured workers faster and for settling claims quicker, those using the traditional systems are at an undeniable disadvantage when competing for work against those in the newer programs.

In addition to impacting competitiveness, WC also impacts the ability of a contractor to prosecute their work. In order to prosecute work at peak efficiency, a contractor must have skilled workers who show up on the job with a mindset to go to work. In other words, the hallmarks of an ideal workforce are loyalty (or at least a positive attitude), skill, and dependability.

If benefits are slow in reaching the injured worker, as is typical in today's traditional state programs, the worker will be longer in getting back to work. This hurts attendance. If a worker feels that "they" mistreated him when he got hurt, he might not be as anxious to get back out on the job. This worker is also likely much less loyal to the contractor than before the accident. Make no mistake. When a WC claim lingers, the contractor is advised by the carrier to stay out of the process. During this time, if the contractor acquiesces and stays out of the process, the injured worker is very likely to combine the carrier who is delaying or denying his claim with the contractor into the "they" that are mistreating him. This not only hurts attendance, but can do irreparable damage to the loyalty that the worker has for the contractor. This workers lower opinion of his supervisor will often result in lower work quality, hurting the contractor's efforts to prosecute the work.

1.1 Background

The original intent of WC was good and noble. Philosophically, it goes back to the basic tenets of workers compensation set forth by Bismark in Germany, c. 1884, which states:

1. Workers should be taken care of
2. The industry responsible for the injuries – not society as a whole – should pay for the care of the injured individual (Kleeberg 2003)

Workers' Compensation is not welfare and the general public should not be forced to subsidize an inefficient or dangerous industry.

The dual role of WC in the United States has always been to:

1. Compensate Injured Workers
2. Provide Employers with Immunity.

Employers frustrated with the current system tend to forget about how things were before WC, when they could be sued by every worker who ever got injured on one of their projects.

As each state originally established their WC programs, each program started with a well-defined schedule of benefits and an administrative process to resolve disputes regarding benefits.

The major benefits of WC to the worker are that in order to receive benefits after being injured, the worker no longer has to prove negligence on the part of the contractor. The system is "No Fault" in nature, meaning that even if the worker is at fault for the injury, he is entitled to health benefits, with the goal being to return him to the work force. Also, the system is self-executing, meaning the injured worker does not need to do anything but report that an accident has occurred in order to start the process toward his receiving benefits.

The benefit of WC to the contractor is limited exposure. Under WC law, the employer is not subject to "pain and suffering" and other subjective circumstances that have resulted in the "big jury verdict," awarding injured workers large sums of money, sometimes millions of dollars, for injuries suffered at work, seen in civil cases. Another benefit to the contractor is that the system of benefits delivery is streamlined.

1.1.1 The Evolution

The first entity to arrive on the scene besides employer and employee is the insurance company. The goal of the insurance company does not match those of employer and employee. The goal of the insurance company is to maximize profits. This is accomplished by maximizing premiums and minimizing payout (benefits). This conflicts with the contractor goals of helping the employee and prosecuting the work and the employee goals of getting healthy and not suffering financial damage from the accident.

This brought on a perceived imbalance of power. A David v. Goliath (Big Insurance v. Employee) situation was generated, which frightened many injured workers. In order to balance the playing field, the employee would retain an attorney. The system was set up so that the injured worker was virtually assured to not have to pay for the attorney. So, today, very often the second entity to arrive on the scene is the plaintiff's attorney.

This sets up a confrontation between two large entities, neither of which shares the goals of the employee or the employer. The plaintiff attorney goal is to maximize their fees and the insurance company goal is to maximize profits. In order to win this conflict, both sides retain professionals to help their case and a whole industry has formed to support these causes and join the original two entities in the WC Litigation Support Industry. These people include:

- Plaintiff's Attorney
- Insurance Provider
- Defense Attorney
- Medical Experts
- Vocational Experts
- Outside nurse
- Rehabilitation Providers
- Pain Management Providers
- Medical Specialists (examples: Psychiatrists, chiropractor)
- Private Investigators
- Pain Centers

1.1.2 Today

Ultimately, the contractor pays for the upkeep of this entire industry. For their money, the contractor who employs an injured worker that isn't satisfied with the settlement offered by the insurance company has the loss of the use of an employee for a possibly extended period of time, a damaged relationship with the employee, a less-secure, less-loyal, and, possibly, disgruntled workforce, and higher WC insurance premiums. Workers talk among themselves and often the employees lump the employer in with insurance provider as "co-conspirators."

2. Common Sense Claims Handling

The likely outcome of any case starts taking shape with the way the contractor treats the original claim. It is natural for the contractor to have negative feelings when informed that a worker has been injured, especially if that worker has been injured before. However, when the worker approaches his supervisor or the contractor to inform them of an injury, that worker is, in all likelihood, anxious, nervous, and possibly frightened. To receive the news of the worker's injury negatively is to possibly set into motion a chain of events that could be very expensive for the contractor.

Almost as important as showing sympathy and concern to the injured worker is the appearance of order and organization. If this already anxious individual perceives that the contractor is disorganized, this can lead to a perception of the contractor not knowing how to handle the situation, which exacerbates the anxiety of the injured worker. The contractor must be prepared in advance for the news that a worker has been injured, so the process is smooth and lets the injured worker know that he is in "good hands," that his employer cares about him.

There must be an established system. The contractor should never send an employee reporting an injury away for any reason. If the company's Safety Officer is unavailable, the contractor should have another employee take the information in a professional manner that will put the worker at ease. Waiting two or three days to take the information and get the process started exponentially increases the likelihood of a substantial claim. More claims are due to psychological pain than physical pain.

2.1 Preparing for and Handling of an Accident

After acting as an attorney representing contractors and insurance carriers in hundreds of cases, the author recommends that the contractor follow the following procedure to ensure the smoothest process possible in the event of an injury to an employee on a project site.

1. **Do Whatever is Necessary to Establish a Solid Safety Program / Record**

   Workers must_feel that the contractor cares for them. Lower accident rates mean lower experience modification rates.

   Communicate With Union About Company Goals

   Of course, this only pertains to union contractors. In the case of non-union contractors, the case should be taken directly to the workers. Inviting the union or the workers to discuss steps to help root out WC fraud has had positive results in the past. The union is more likely to help if they think the contractor is helping their members. This is not always practical due to labor relations at any point in time in any location, but usually the contractor can find common ground with the union on this issue. Even when unions have close political relationships with the Trial Lawyers organizations, they are often receptive to a message of "Let's take money out of attorney and carrier pockets and put it in the worker's pocket." In this scenario, almost assuredly, more will stay in the contractor's pocket also.

2. **In Case of an Accident, Don't Treat the Injured Worker Any Differently than Any Other Worker**

   A contractor should try to make the injured worker feel as comfortable and cared-for as possible. Not only office personnel and Safety Officers should be ready to handle injury cases. Foremen and superintendents should be trained in putting the injured worker at ease, both at the time of the accident and when the worker returns to work. Communication is key. Usually, the insurance carrier wants the contractor to disappear and let them handle it. This is a mistake. It is the contractor's right and duty to stay in contact with the worker.

3. **Stay on Top of the Claim**

    Insurance adjusters are incredibly overworked, and typically handle 100-130 claims at any time. A contractor's case isn't the most important claim unless the contractor makes it so. As stated earlier, the employer has the right and duty to know the status of the claim and to insist that benefits are delivered in an appropriate and timely manner.

4. **Facilitate Return to Work**

    The contractor should always make light duty available. This duty must be a real job and can't be perceived as a badge of dishonor or as a way to belittle them or "run them off." Being treated with dignity has been shown to have a positive effect on an employee with character.

5. **The Contractor Shouldn't Let the Insurance Carrier Pull Them Into an "Us v. Them" Relationship.**

    The carrier's interests, as discussed earlier, are not the same as the interests of the contractor.

In short, preconditioning, coupled with a hands-on approach to WC, do things to build bridges with employees before an accident ever happens.

3. Understanding Risk Management

Insurance carriers often portray a two-dimensional relationship between the amount of money a contractor spends for WC insurance and the level of loyalty that said contractor can expect from his workforce. The scenario depicted in this scenario does not coincide with reality because it is an over-simplification that doesn't address the third dimension that is acting on the relationship between the employer and the employee, and thus between the injured worker and the insurance carrier. Unfortunately, the figure represents the picture typically painted by an insurance carrier as it attempts to convince a contractor to spend more money for WC insurance. The Third Dimension is described in the next section.

4. Third Dimension

There is surely a third dimension that the insurance carrier doesn't want a contractor to think about, or, if possible, to know about. This third dimension includes several items and costs, some of which the carrier can control, some not. These items in the third dimension include:

- Delay in employee receiving benefits
- Insurance carrier cut ($)
- Administrative Cost
- Claim Cost
- Litigation Cost
- Expert Witness Cost
- Increase Medical Expense due to litigation

- Extended Recovery Time

Some of these costs will be deducted from the injured worker's benefits. Others will cause the contractors premium amount to increase. All of these costs come out of someone's pocket and more often than not, it finds its way back to the contractor.

There are other things hidden in the Third Dimension that a broker will almost surely not tell a contractor about. These are alternative WC programs, innovative and creative in nature that a typical broker cannot offer to a contractor. This is why, even if they know about it, they won't share the information with a contractor. Before introducing the alternative programs, a short explanation and analysis is offered of the traditional program available in all states.

5. Options for Workers' Compensation Programs

There are several options for most contractors when it comes to their workers' compensation insurance. Each state has different statutes, and therefore some contractors have more options than others. Each state has a traditional, or state system and the co-author, a workers' compensation attorney for over 25 years, believes that no state could prevent any form of self-insurance discussed in this paper. Negotiated Workers' Compensation, however, along with its derivatives, are not legal in the majority of US states.

5.1 Traditional System

Most contractors are working within the traditional system. Each state's system has its own unique details, but for the most part they are all the same. Basically, a carrier is eligible to write insurance in the state and brokers and salesmen sell their products for them in the state. The contractor decides what product is best for his firm and that is usually the extent of the influence the contractor wields as the carrier "takes it from there."

5.2 Negotiated Workers' Compensation

Negotiated worker's compensation (NWC) is a form of WC that is fundamentally separate from the statutory WC system in the states where it exists. NWC is an alternative system for regulating WC in which an employer may either purchase voluntary coverage (market-based) or be self-insured but ultimately retains the ability to resolve disputes with injured employees through the medium of a private system of resolution, as provided for by state law.

The alternative dispute resolution (ADR) process internal to all existing NWC systems is conducted through entirely private means; therefore, it is not reliant on any function of the state government or the statutory system of WC for purposes other than:

- the establishment of the legality of the NWC system,
- the administrative regulation of the NWC system, *not* the individual case, and
- the serving of as an appeals mechanism for the NWC system.

For the purposes of this paper, NWC is composed of two subsets: collectively bargained worker's compensation (CB/WC) and substitute compensation systems (SCS).

5.2.1 Collectively Bargained Workers Compensation (CB/WC)

Collectively bargained WC may be seen as a system of NWC, as established through a collective bargaining agreement, where permitted under state law. Ten states are known to possess CB/WC provisions within their statutes. A CB/WC provision is characterized by the inclusion of language that alludes to union involvement through the use of an authorized bargaining agent or representative, as well as a level of specificity regarding what general types of programs are permitted for inclusion in the NWC system.

5.2.2 Substitute Compensation System (SCS)

SCS is a system of NWC, established where permitted under state law. Five states are known to possess SCS provisions within their statutes. An SCS provision is characterized by the absence of language in direct reference to union involvement and an ambiguous, and thus permissive, nature regarding what general types of programs are permitted for inclusion in the NWC system.

5.2.3 Alternative Dispute Resolution

Alternative dispute resolution systems are generally distinguished from traditional litigation by the nature of the process and the presence of third-party neutral stakeholders, such as Ombudsmen, Mediators, and Arbitrators. Simply, ADR is a mechanism for the resolution of disputes, which operates external to the traditional dispute resolution function. Generally, there are three possible levels of ADR found in a NWC system: ombudsman, mediation, and arbitration.

Ombudsman: The term *ombudsman* is likely to have diverse meaning dependent upon the context in which it is being used. Generally, it is the first level of dispute resolution in an NWC setting. An ombudsman will perform one or both of the following functions related to NWC:

- Act as a contact and information provider for the injured worker. Many WC entities have successfully used the services of an ombudsman in an anticipatory manner in order to, in a sense, solve problems before they occur.

- Act as an informal arbiter, primarily through the facilitation of communication between parties, in a manner simpler than that of mediation.

Mediation: A consensual process in which the parties agree on the resolution of the dispute themselves with the help of a mediator. This is usually accomplished by walking the parties through a series of stages: agreeing on ground rules, identifying facts and positions, promoting mutual understanding, developing mutually acceptable options, and, finally, agreeing on the option that best resolves the dispute (Levine et al 2002).

Arbitration: An adversarial process in which a neutral third party decides disputes in an informal proceeding. Generally, the arbitration process is not bound by traditional rules of evidence or procedure. The arbitrator's decision, by definition, is binding and final and cannot be appealed on substantive grounds (Levine et al 2002).

5.3 Self-Insurance

There are several programs that fall under the broad heading of self-insurance. These range from the very simple (a large employer simply insuring itself, with a catastrophic re-insurance policy from a carrier) to more complicated programs. While true self-insurance limited to very large companies, companies of any size can get involved with some of the more creative systems.

5.3.1 Small, Exclusive Self-insured Pools

In 1976, rules for self-insurance associations were onerous, but then changes in state legislation around the country made self-insurance a more reasonable alternative. According to a top WC attorney working mostly with these pools, associations were formed, mostly in the construction industry, where contractors involved in these systems are active participants (they, in a sense, own the insurance "company"). The association then buys catastrophic insurance from a traditional carrier, with a typical deductible of $250-300,000. The association contracts with a third-party administrator (TPA) to run the program. Premiums for members are set using established state mandates, and the TPA has claims specialists who decide how to handle a claim (Plagens personal interview 2005).

A recent case illustrates the priority an employer places on its WC program when he "owns" the program. A manufacturing company in a small self-insured group had a dispute in litigation. The third in company rank had long-standing plans to take a combination business and pleasure trip to Austria; however, when the date for a hearing was set that conflicted with his trip, he cancelled the trip. One attorney said, "I've never seen anything like that from a company that simply lets an insurance company handle everything." When the claimant's attorney heard that this man had cancelled his trip, he advised the claimant to settle, which he did (Plagens personal interview 2005).

One contractor that is a member of a small (five contractors) self-insured group in Minnesota described the group in an interview. The group has been in existence since 1991 and consists of five sub-contractors. The interviewed contractor is the only electrical sub-contractor in the group. The group is always looking for new members but is selective. To be considered for membership, any applicant must have:

- a documented, anticipatory - not reactive - safety program
- financial strength (Rademacher personal interview 2005)

The group has two meetings per year in which members set premiums in the fall and review the year and address any unresolved concerns in the spring. At the spring meeting, most members get refunds in the form of retro-premiums. It is rare when any group member does not receive a refund. In fact, since the group has started, there has been only one year in which each member did not receive a refund. That year, two contractors had to remit additional funds.

The pool has a $200,000 deductible with catastrophic coverage from a major insurance carrier, and the member-contractor states that "We have maximum input and control of our own claims and premiums." The State Department of Commerce (DOC) regulates the group and assigns modification factors, calculated using DOC formula. The rate set was about $3.15/$100.00 for the last year, but the self-insurance pool is only good for work done in Minnesota. The insurance carrier that holds catastrophic coverage covers out-of-state work for the members.

5.3.2 Large Independent Self-insured Pools

Currently, the WC community in Kentucky is reeling from the collapse of a large self-insured pool, Associated Industries of Kentucky (AIK). The ramifications of this collapse are at least two-fold: 1) all members and former members of the group now have to reimburse the state because the state had to assume the payments to injured workers covered by AIK, and 2) the unfavorable position in which these employers find themselves is causing them and many of their fellow employers to be somewhat reluctant to use anything but the most traditional programs.

There are other large self-insured pools in Kentucky. One that is particularly popular with contractors is the Associated General Contractors (AGC) program, which has hundreds of companies enrolled, not all of whom are contractors. The program uses a TPA, but the TPA does not get involved unless there is a dispute (Walsh personal interview 2005).

6. Summary: Advantages and Disadvantages of the Options

Each system offered as an option has its advantages and disadvantages. These are listed here.

6.1 Traditional System Advantages

The biggest advantage of the Traditional system is that coverage is easily obtained. Some states have systems that will not turn any contractor away based on EMR. Another advantage as perceived by some is that no contractor involvement is required or desired.

6.2 Traditional System Disadvantages

Disadvantages of the Traditional System include high premiums, high settlements, slow delivery of benefits, and high attorney involvement. Also, the system tends to contribute to adversarial relationships between the parties and in many states, participants complain and show evidence that they don't get a fair hearing because review boards are stacked with political appointments that tend to favor either the employer or employee to the extreme. In Illinois, for example, the contractors and carriers have ceased appealing to the review board if they think that they have been wronged by a decision of a lower level arbiter or mediator because the decisions of the review board almost always award the injured worker even more than the amount that the contractor or carrier thought was excessive in the first place. Fraud happens more frequently in this system than any other and the carriers really frown on contractor involvement, leaving the contractor ignorant of the status of any case, and contractors often complain that in this system, the carriers "cave in" to complainant attorneys, agreeing to large settlements in cases where the contractor thinks that the injured worker is not entitled to anything, or much less than the carrier is offering.

6.3 Negotiated Workers' Compensation System Advantages

The main advantage of Negotiated WC is that it limits or eliminates attorneys until very late in the process. This leads to faster settlements, settlements of a more reasonable amount (since there is no jury or judge “sending a message” to the industry by rendering a very high settlement. There is time required of the contractor, but not as much time involved as with small, exclusive pools.

6.4 Negotiated Workers’ Compensation System Disadvantages

The two disadvantages to Negotiated WC deal with perception and time. The perception is that there are limited choices of providers. This has been proven to be untrue, but the perception remains. The time factor is simply that there is more time involved on the part of the contractor in Negotiated WC than with Large, Impersonal Pools or the Traditional (State) System.

6.5 Self Insurance System Advantages

Since the contractor is basically acting as his own WC provider for all injuries short of catastrophic, the advantages are simple. The premiums, usually for catastrophic coverage only, are the lowest for any system. Also, the system also affords the highest level of control and self-determination to the contractor of any system.

6.6 Self Insurance System Disadvantages

The disadvantages to this system are just as simple and just as obvious as the advantages. Operating and maintaining the system is very time consuming for contractor, and since the contractor is responsible for any settlement under a certain amount (usually $250,000 – $300,000), the risk for the contractor is the highest of any system.

6.7 Small, Exclusive Self-insured Pools Advantages

There are four main advantages of small, exclusive self-insured pools. First, this type of system allows (encourages) contractor participation and ower premiums than with the traditional system are likely. Unlike with traditional systems and large self-insurance pools, only the group-member company that has a “bad year” pays for it. Finally, testimony of those interviewed by the researcher unanimously attested that attorneys are intimidated by this system and tend to settle quickly.

6.8 Small, Exclusive Self-insured Pools Disadvantages

The program requires a high degree of contractor participation since the contractor is essentially a board member for the insurance provider. Also, there is the risk that several member companies could all have a bad year the same year and not be able to pay for it. If enough members have a bad year the same year, the program could collapse

6.9 Large, Independent Self-insured Pools Advantages

The biggest advantage of a large, independent self-insured pool is likely lower premiums. Also, for the contractor that does not want to be closely involved with the operation of his WC program, it is an advantage that contractor input is neither needed nor desired.

6.10 Large, Independent Self-insured Pools Disadvantages

Among the disadvantages of this system is if a contractor wants go know the details of his program, or make a decision regarding the disposition of a case, he will find that contractor input is not welcome. There are also High settlements and Slow Delivery of Benefits. This system also tends to contribute to adversarial relationships, perhaps because of high attorney involvement. Fraud happens too frequently in this system an in many states, like with the traditional systems, the outcome of any case that goes before the review board is almost decided before it gets there, and for the same reasons discussed above in regard to traditional systems.

7. Conclusions

The average US construction contractor is too busy trying to procure and execute work to know much about the company's workers' compensation insurance. All they know is that its expensive and most will say that there is too much incentive and opportunity to commit fraud. There is no one-size-fits-all when it comes to choosing the best plan for a contractor, though all the state systems either make their contractors all use essentially the same system, or would if they could.

Each of the 50 states has its own set of workers' compensation laws, which make a single remedy that would fit each state impossible; and an analysis to fit the best system to each set of circumstances in which a contractor might find itself is beyond the scope of this paper.

Not every option listed in this paper is legal in every state. For instance, Negotiated Workers' Compensation is only legal in 16 states at the most. Ten states have specifically legalized it and six states have not made it illegal. However, it would behoove every contractor to determine what kind of workers' compensation systems are legal in their state, and to analyze each in light of their own circumstance to choose the system that is best for them. To educate themselves as to the details, advantages and disadvantages of each, studying the contents of this paper would be a good place to start.

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Energy renovations – an opportunity for the construction industry?

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Abstract

The building stock represents a significant part of energy consumption outside the emissions trade sector. In warm countries, energy is spent on cooling spaces and heating water; in northern countries, it is spent on heating spaces and water. In countries with cold winters, conditions have forced investments in energy-efficiency. The increased efficiency measures now required, such as a 20 per cent reduction in energy consumption, are significantly more difficult to achieve than they are in countries where the building stock actually wastes energy in terms of unit consumption data.

Energy economy studies have been carried out since the energy crises of the 1970s. The final result has been that with the savings achievable from energy consumption, the repayment periods of energy renovations are unreasonably long. This does not motivate house owners, nor does it increase the interest of investors to invest in renovations or improving energy efficiency. Using directives to obligate energy renovations will emphasise the location of the property even more. Depending on the location, the same renovation may constitute 20 or over 100 per cent of the property value.

In order to achieve a wide-scale improvement in the energy efficiency of the building stock, a forward leap is required in renovation operations. Small renovations or modifying new construction concepts are not enough to achieve the set goals. This study tests how renovation construction technologies and productivity could be improved by applying means used either in the renovation of fields of industry or that have lead into the birth of new fields of industry. A case study is used as the research method. According to preliminary research, it seems that countries with an industrially constructed building stock will require an entirely new field of business, and new kinds of companies or networks of companies for the near-future energy renovations. In the long term, the construction industry could adopt practices from other fields of industry producing capital goods, where the aftermarket, or renovations, are taken into consideration when planning new investments.

Keywords: building stock, construction industry, renovation, upgrading

1. Introduction

The EU Energy Efficiency Directive aims to promote the energy efficiency of the existing building stock as well as new buildings (European Parliament; European Commission, 2010). In comprehensive renovation projects the goal should be to meet the requirements set for the overall energy consumption of buildings, in the repair of individual structural elements to meet the requirements for thermal insulation capacity, and in renovation of heating system to favour renewable energy sources. The public sector is obliged to serve as a trendsetter.

National applications will be made of the directives which take into account outdoor climatic conditions, local conditions and requirements for indoor climate as well as cost-effectiveness. This is of utmost importance since the European countries lie in area extending from the subtropical to the cold zone. The range of climatic zones is thus only slightly narrower than in North America. Cost-effectiveness is affected significantly by e.g. the standard of living of a country and related labour costs.

Improvement of the energy efficiency of the building stock is not a new issue. Related measures have been demanded since the first serious energy crises of the 1970's. Since then new construction has become more energy efficient meaning that the building stock becoming of renovation age is already relatively energy efficient. Renovation of the building stock has been minor until recently. Low demand has not created supply. Neither has there been active supply to create demand.

2. Challenges of the renovation markets

For the construction industry, renovation has been a secondary market to even out cyclical fluctuations in new construction. For the companies, operating in several market segments is important for continuity of their business since such companies have proved to be more long-lived than specialist companies. Due to its secondary market nature, renovation uses the same products and applies the same implementation processes as new construction. Renovation is developed on terms of the primary market, new construction. That has neither advanced renovation nor introduced innovative solutions to the markets.

The existing building stock must be renovated to improve its eco-efficiency. Renovation – especially energy-renovation – markets must be made to function (Vainio, 2011a). There are several possible paths (Vainio, 2011b). That can be accomplished by existing renovation companies increasing their supply (sustainable development concept) and new construction companies expanding their supply (ambidextrous concept). The revolutionary model (disruptive concept) of the IT sector model could also be an alternative. These possible paths are based lightly on theories of technology change (Hamel, 2000; Kim & Mauborgne, 2005; Christensen, 1997).

Improvement of energy efficiency is a joint global aim. Property owners can be led to do it, not forced. The real estate business must be profitable. The ability and willingness of both companies and private individuals to pay rent is limited. Many other renovations, such as interior renovations, are visible and bring concrete benefits to space users. On the other hand, many energy renovations are invisible expense items to users.

Introduction of tight regulations in renovation that require energy renovations may delay them and thereby weaken the condition of the building stock, unless they are economically justified. If entire renovation projects are eliminated, the renovation markets will contract and companies' interest toward the segment decreases further.

Reasonable requirements would promote growth of renovation. Some advanced products and services suited for energy renovations are already available. Yet, there would be demand for new innovative production processes, products and services with a reasonable payback period (< 10 years).

This article tries to determine which of the three alternative factors solves the equation of challenging local conditions: how can energy renovation be promoted in cold climate in a country with a high price level. In countries with cold winters, like Finland, investments in energy efficiency have been made since the first energy crises. Thus, energy renovations of the building stock can bring only minor savings, which means that payback periods become unreasonably long. That does not motivate owner-occupiers or investors to invest in repairs or improvement of energy efficiency.

3. Research question and method

The key research question is what level of energy requirements would cause people to undertake renovations while also being challenging enough to meet the targets set for energy efficiency in international agreements (case Finland). Yet, the setting of a level is not an end in itself – the measures must also be implemented. This issue will be dealt with in more detail in the discussion chapter.

During autumn 2011 this study collected the experiences of property owners and their sector organisations on the means to reduce the energy consumption of buildings in a cost-efficient way. Experiences were collected through personal interviews and discussion meetings.

The starting point and background of the interviews and discussions was the directive enacted in 2010. Interviews were conducted at a time when national regulations were only being planned to collect experiences from the field. Thus, the interviewees could influence the preparation of regulations.

Open-ended questions were asked about the following themes:

- impact of energy-efficiency demands on decision-making
- profitability of renovation measures that improve energy-efficiency
- how can the energy-efficiency of the building stock be increased
- availability of energy-renovation services.

The respondents represented the following types of property owners:

- residential rental companies (2)
- non-residential rental companies (5)
- lobbying organisations for the above (2)
- lobbying organisations for home owners (2)
- companies providing renovation services (3).

Property owner can be divided roughly in two groups. For one, properties represent their core business resource – a means of generating revenue. For the other, properties are primarily a basic commodity. The difference between these two groups is that in the case of the former properties generate cash flows of revenue and expenses and the operating profit. The latter, again, pays the expenses of a property out of other income. In both instances decision-making is influenced by financial considerations.

Nine of the interviewees belonged to the first group. Seven of them answered the questions based on experiences from their own properties. None of them was an energy expert; all were facilities management professionals. The interviewees representing both the real estate business (2) and homeowner lobbying groups (2) were energy experts, and their views were based on information from their members and conducted studies.

4. Summation of interviews

4.1 Impact of energy-efficiency requirements on decision-making

According to the interviewees, tenant turnover is an essential aspect of the property business. Space renovations take place in that connection to meet users' spatial needs. The changing of tenants does not happen optimally with respect to the technical repairs required during the life of buildings. In non-residential buildings the interest for energy renovations is decreased by the minor need of heating in relation to other energy consumption. The interviewees brought out the fact that the energy consumption of existing buildings (with few building services, etc.) actually increases after renovation.

Those engaged in the property business estimated that if regulations bring extra costs, renovations of the stock rated poor can easily be forgone. Properties will rather be sold to be developed or demolished when regulations lead to so-called unprofitable renovations. Extra energy renovations may also delay economically sensible renovations until they cannot be avoided.

Owner-occupiers were believed to undertake repairs that increase energy-efficiency only if they bring actual benefits. Tearing down of buildings is not likely to increase, at least in growth centres, but the conditions of buildings will deteriorate. The interviewees were convinced that small, poorly equipped buildings will in any case be demolished to make way for new better equipped ones. Elderly owner-occupiers do not find energy investments sensible as they think that their building will last for their remaining life-time without renovations. This mindset also prevents other reasonable and technically necessary repairs in buildings.

Part of the interviewees thought that some buildings have from the outset been designed for short-term use, and a conscious strategic choice has been made to use the buildings until ready for demolition. Part of these buildings are in net out-migration areas where no sensible use for vacating buildings exists. In growth areas changes in the operating environment also cause uncertainty about the continuation of operations which calls into question investments in properties.

In the case of energy renovations to usable buildings, fears about problems created by renovations and high costs were mentioned as impediments. There are also environments and buildings whose cultural-historical or architectural value overrides the demands for energy-efficiency. The interviewees opined that energy-efficiency renovations are considered categorically unprofitable although earlier unprofitable measures have become profitable as technology has improved.

4.2 Profitability of renovation measures that improve energy-efficiency

Interviewees found that there is less sense in making energy renovations as a result of intermediate repairs such as adding extra insulation to external walls which may require rebuilding roof structures and the plinth. Interviewees considered the following additions expensive compared to their benefits:

- extra external wall insulation because the energy savings are small compared to renovation costs
- internal extra insulation since intermediate floors are not insulated and act as cold bridges
- centralised ventilation and related heat recovery in blocks of flats if the building has natural ventilation or just mechanical exhaust ventilation
- exhaust air heat pumps of district-heated buildings (1/3 of energy savings consumed by electricity more expensive than district-heating energy)
- renewable energies, with the exception of solid fuel, increase energy consumption
- solar heating and electricity and wind power are expensive investments compared to the energy generated.

It was acknowledged that measures to improve energy-efficiency become more profitable when scheduled to coincide with other renovations. Investment in energy-efficiency was estimated to increase renovation costs by 10−15 per cent. On the other hand, if the subject of a measure that increases energy-efficiency is a sound structural element, the costs of its entire renovation are taken into account.

The interviews established that regulations are needed and property owners can be forced to implement profitable energy renovations. Property owners consider the following to be profitable renovation measures that improve energy-efficiency:

- extra insulation of roof substructure
- new energy-efficient windows and external doors if in need of replacement
- improvement of tightness of walls
- heating system changes especially when the old system has reached the end of its life. It pays to switch from oil to geothermal heating

- infill construction where waste heat of existing buildings can be used to heat new ones.

4.3 How to promote energy-efficiency renovations

It was suspected that support to energy renovations would increase prices and thus be a questionable means. Financial support is available for a limited number of projects, but public funds will not stretch far. Rather, investment in energy renovations should be long-range and comprehensive targeted at design competence and development of products and systems specially tailored for renovation. Many solutions copied from new building were considered too expensive for renovation.

Knowledge about means and effectiveness were deemed sufficient for property owners that pay their own energy bills. The lack of calculators, etc. that allow determining the impact of measures on energy use and costs was evident.

According to the interviewees, the building regulations planned for renovation apply only over a short period of a building's life. Measures undertaken during use, such as regulation and monitoring of building services systems, can have a bigger impact than renovations on adhering to target values. The following were considered cost-effective tools for achieving energy-efficiency:

- maintenance manual, condition assessments, energy consumption management
- energy-efficiency agreements, inspections and certificates.

4.4 Availability of energy renovation services

The responses of different types of property owners differed as to the availability of renovation services. According to companies engaged in the property business, the key issue is competent project management or discerning demand to which supply adjusts. Representatives of residential property owners expect short supply to raise prices and bring foreign labour and unskilled workers to the markets.

Property owners informed that renovation services are provided by specialised companies as well as new construction companies. Large construction firms have, however, divided new construction and renovation into separate divisions. They are only interested in sufficiently big renovation projects and, for instance, own property development projects.

5. Discussion

The different life times of structural elements are reflected in the structure of renovation. The life time of structures and many systems is clearly longer than that of surfaces, equipment and accessories. The actual life time of the latter is shorter because they are renewed for other than technical reasons, for instance in connection with changes in occupancy and spatial alterations. Changing of tenants in non-residential and residential spaces often leads to renovations not necessitated by age.

Thus, renovation has naturally involved demand for indoor phase works, finishing and installation of building services equipment. The implementation of these tasks at a renovation site closely resembles closely the work at new construction sites. The same applies to the energy renovation measures considered profitable – thermal insulation of the roof substructure and replacement of windows and external doors.

A common feature of profitable energy-renovation solutions is that they are ambidextrous concepts: suited for both new construction and renovations and industrially prefabricated. Industrial prefabrication improves overall productivity of the renovation process, which is important in a country with high labour costs. An essential factor from the viewpoint of energy efficiency is the development of products' properties and investment in marketing in order to make property owners choose the best products in this respect.

The interviews clearly manifest property owners' cautious attitude toward energy renovations. Should energy renovations proceed accordingly, i.e. if energy renovations deemed profitable were to be implemented in the Finnish building stock in connection with renovations related to other causes, the energy consumption of the building stock would fall 0.5 per cent annually. That is equal to the contribution of the lost building stock to energy consumption.

Even this estimate may be overly optimistic. In a country of similar culture and conditions, Sweden, it has been discovered that only 10−30% of profitable energy renovations are made (Göransson & Pettersson, 2008). The reasons are the following:

- the organisation does not have the interest, time or competence to delve into energy efficiency issues
- there are doubts about the situation remaining as it is
- knowledge about possibilities to conserve energy is incomplete or false
- profitability is viewed too critically or short-sightedly
- there may be problems with financing.

The interviewees considered monitoring and different calculators the crucial tools in improvement of energy-efficiency of the building stock. One can evaluate the profitability of renovation measures only if the impact of the energy consumption level of a property and potential measures is known. The use and impact of the tools on decision making as well as the meeting of demand and supply are manifested in how the increase in the price of oil multiplied the geothermal and air-to-air heat pumps energy production by ten (Official Statistics of Finland).

These products save money and cut emissions, but do not increase the energy-efficiency of the building stock, nor are they suitable for all buildings. The most demanding targets in respect of energy-efficiency remain feasible alternatives. A totally new approach to them is required, such as the disruptive approach. Renovations should give buildings properties that sell themselves to clients while also improving energy-efficiency. Then people would not be as critical of the profitability of energy renovations and measures discarded as unprofitable for the time being could be implemented. The stock rated ‘poor’ and discarded by property owners could be used as test sites and product development platforms.

In earlier discussions about using the disruptive approach to increase energy renovations, renovation as a whole was considered a niche market. That is, companies developing the concepts of renovation could grow and occupy the building construction markets while old companies focus on the main market or new construction. Yet, it appears that the niche market includes only a part of renovation. It may be something presently subject to active research, but still too expensive for the mass markets.

6. Summary

Renovation of the building stock has been considered a potential market for construction companies. The issue always surfaces when demand for new construction falls radically. Since the building stock consumes a lot of energy, it has been regarded as the target that offers the most potential for reducing energy consumption and related greenhouse gas emissions. These two views merged during the global financial crisis and focused public interest on energy renovations to the building stock as a means of fighting climate change and the economic recession.

After the initial excitement we are returning to square one. Energy renovations cannot be an end in themselves, but must be part of normal maintenance and repair during the life cycle of buildings. In countries with cold winters, buildings have from the outset been built reasonably energy-efficient. That is a challenge to profitability of renovation measures. A feature of profitable energy renovations in a cold winter climate is that the products used are suited for new construction as well as renovation. The products may as well be locally manufactured tailored products or mass products from international markets.

All products and systems of new construction are not, however, naturally suited to renovation and consequently lead to economically unsatisfactory solutions. Energy renovations require their own solutions. Their provision requires either demand to guide product and service development or active supply to awaken the interest or demand of clients. The interviews and observations on markets showed that property owners are both cautious and bold. They are cautious about renovating the old, but bold about introducing new technology when it is available at reasonable cost.

Renovation in general, and energy renovations specifically, require competent and innovative service offering, which is created by

- commoditising specific and generic research results for renovation
- large-scale exploitation of new technologies in products and production processes
- business concepts diverging from the mainstream, and
- marketing based on the example of successful projects.

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Examining The Trends In Building Material Prices: Built Environment Stakeholders' Perspectives

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Abstract

The paper investigates the trends in building material prices in South Africa. It examines whether there are differences in the perceptions held by built environment stakeholders, of the key factors that affect building material prices based on their profile, giving that there are various stakeholders in the built environment and their views may differ significantly. The rational for the examination stems from the lack of knowledge about the perspectives held by stakeholders as to what is responsible for the trends in the prices of building materials, and whether these can be benchmarked to actual economic indicators determined by statistical analysis. Knowledge of the key factors contributing to these trends is a step towards finding solutions to problems of project abandonment and gaps between the demand and supply of basic infrastructure prevalent in the industry. The paper provides information on building material price trends, and proposes a framework that will produce stable building material price levels.

Key Words: Building Material, Cement, Perception, Price, Steel and Volatility

1. Introduction

The 2010 soccer world cup was a milestone that brought about significant changes to the South African construction industry. The public and private sector made significant investments in major projects such as world-class stadiums, transport systems – roads and railways, and accommodation. However, at the helm of all these projects lie building materials and their costs. Generally, it has been estimated that building materials and building components constitute between 35-60% of total construction cost (Bourne, 1981; cidb, 2007; and Windapo and Cattell, 2010). The large proportion of building materials in construction project costs make it an important component which has an enormous effect on the cost of construction and essentially the affordability of newly proposed construction projects.

A study of built environment stakeholders in South Africa by Windapo and Cattell (2010) revealed that the key challenge perceived to affect the performance of the construction industry and projects in South Africa is primarily the increasing cost of building materials. Although, price increases are inevitable and will occur at some point, cidb (2007) observed that increases in the prices of some building material products are more rapid than that of others. If the price of material moves up and down rapidly over short time periods, it is said to have high volatility and if the price almost never changes, it has low volatility (Investor Words, 2004). According to Cross (n. d), volatility is the predictability of the price and availability of a construction material. Li (2001) noted that volatility pushes costs up and transfers major risk to all parties involved such as suppliers, contractors and clients, resulting according to Ashuri and Lu (2010) in building contract price fluctuation, changes in contractors' profit margins in the absence of any provision in the contract (Chappell, Cowlin and Dunn, 2008) and major financial stress and difficulties within the project lifespan.

The cidb (2007) Report indicates that the volatile building materials in the South African construction industry are steel, cement, sand, copper, timber, PVC, bitumen and masonry blocks/bricks, which according to the Engineering News document cited within the cidb report, have increased up to 100% between October 2000 and October 2006. The questions therefore are is there a noticeable trend in changes in building material prices? What causes these price changes and why does the price of an item of building material rise more steeply or less steeply than other building material prices? In order to provide answers to these questions, the paper first presents the trends in prices of volatile building materials in South Africa within the last twenty years (1992-2011). Secondly, it identifies the materials, which have the most volatile prices. Thirdly, it examines whether there are differences in the perception held by different construction industry stakeholders of factors that affect building material prices based on their profile. Fourthly, it benchmarks the results of the perception survey of built environment stakeholders regarding the key factors responsible for the changes in building material prices with statistical evidence. Lastly, the paper makes proposals for an enabling environment that will promote stable building material price levels.

2. Trends in Building Material Prices

The graphical representation of the trends in the prices of cidb (2007) identified volatile building materials in South Africa between 1992 and 2011 (a twenty year period) is shown in Figures 1a and 1b.

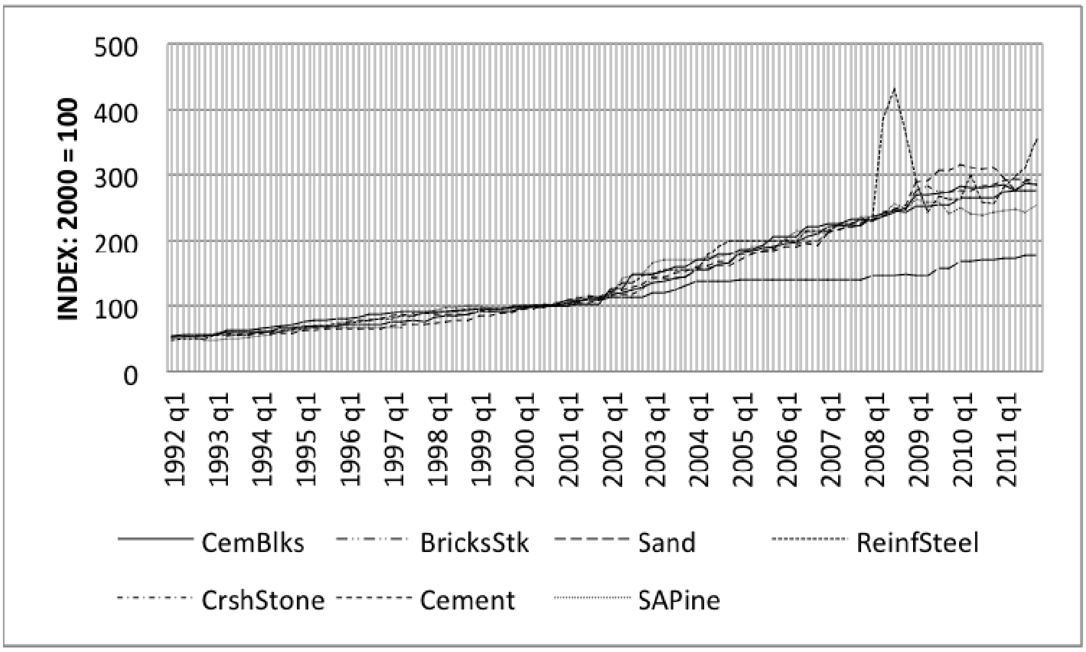

Figure 1a: Trends in Selected Volatile Building Material Prices Quarterly Data (1992-2011)

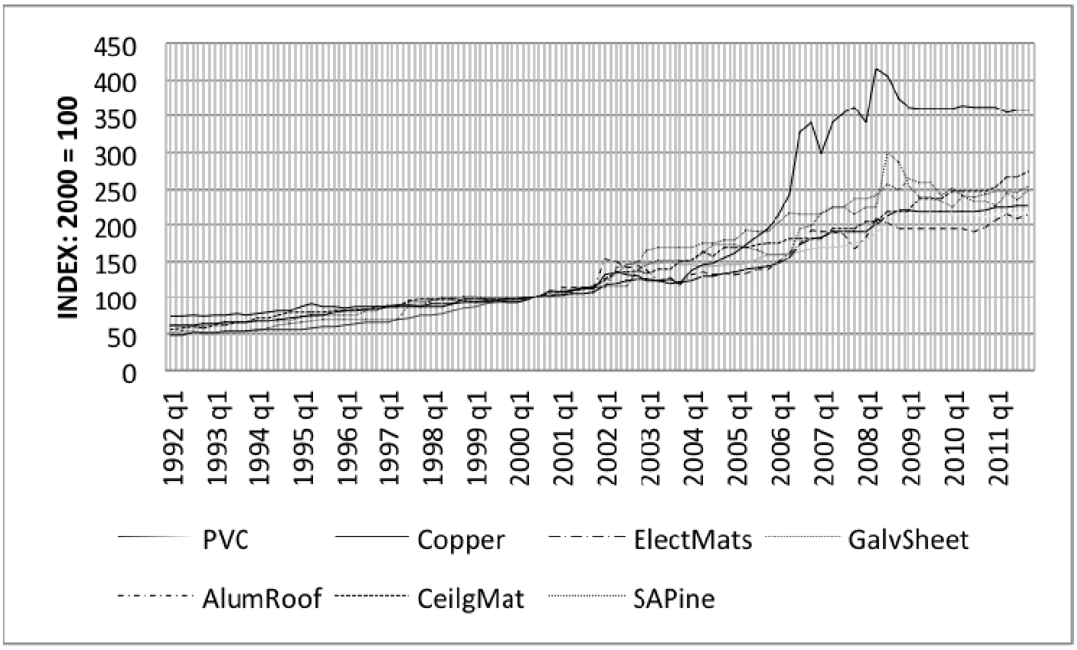

Figure 1b: Trends in Selected Volatile Building Material Prices Quarterly Data (1992-2011)

Source: Department of Trade and Industry (dti) South Africa Online Resource (2012)

Visual inspection of Figures 1a and 1b show a definite increase in the cost of the identified building materials over the past two decades. It emerged that the building materials all increased consistently in year-on-year escalation up till 2001. After 2001, a distinct trend that can be seen is the volatility in the prices of reinforcing steel, cement, copper and galvanized roofing sheet, and the least increases in the price of sand.

Reinforcing steel, cement, copper, galvanized roofing sheet, crushed stone and cement blocks experienced the highest price increases when compared to the other building materials studied. For example, the price indices of reinforcing steel and cement increased in a space of ten years from 104.1 and 105.1 respectively in 2001, reaching a peak of 432.5 in 2008 for reinforcing steel, and a peak of 316.3 in 2010 for cement, before decreasing to current levels of 357.5 for reinforcing steel and 285.1 for cement. Representing 253%-328% and 180%-211% increases in the prices of steel and cement within the last ten years (2001-2011). Copper and galvanized roofing sheet increased from levels of 105.2 and 110.3 respectively in 2001, reaching peaks of 415.1 for copper and 299.5 for galvanized roofing sheet in 2008.

On the other side of the spectrum, it can be seen from Figures 1a and 1b that sand, aluminium roofing sheet and electrical materials in order of magnitude experience the least increase in price when compared to the other volatile building materials, increasing from an index of 109, 114.6 and 104.6 in 2001 to their current price index levels of 176.5, 213.3 and 226.5 respectively. The low increase in the index prices of sand should be expected because sand is a low value product that is characterized by its place value, which means the location of the deposit with reference to the market.

It can be gathered from the foregoing that there has been a definite increase in the prices of building materials over the past twenty years in South Africa, materials such as reinforcing steel, copper and cement increasing more rapidly and also more volatile in price changes than the other materials. Current levels of the price indices of the identified building materials show that apart from sand, aluminium roofing sheet and electrical materials, all the other materials including stock bricks, ceiling materials, SA pine-kiln dried wood and galvanized roofing sheet have all increased exponentially by at least 150% within the last ten years.

3. Review of Factors Contributing to Trends in Building Material Prices

The following are established economic factors that contribute to increases in building material prices:

- **Supply and demand**

  According to Lipsey and Chrystal (2007), the demand for and the supply of building materials or lack thereof, can contribute to the trends in the prices of building materials, where the law of supply and demand can be related. Ortbals (2004) noted that cement and reinforcing steel feel the effect of demand rising with no matching supply the most.

The market conditions also bring about situations in which the effects of demand and supply may affect building material price levels. Rakhra and Wilson (1982) acknowledged that building material price increases are dependent on the market conditions under which they are produced. For example, they noted that material price increases would be more rapid and higher for materials produced by only one or two companies, compared to those for which many manufacturers compete for the same market.

- **Transportation**

Sinclair, Artin and Mulford (2002) noted that increased material cost is primarily due to increased transport charges. Further, high transport and freight costs have been identified as the factors responsible for building material price increases in African countries such as Nigeria, Uganda, and Kenya (Mathews, 2009; Mwijagye, 2010; and Editor, 2011).

- **Energy Costs**

According to Bureau of Economic Research (BER) (2008), high-energy costs have a knock-on effect on the production processes of most construction materials in South Africa, because manufacturers have to increase building material prices to wage off the increases in high-energy costs.

- **Raw Materials and Input Costs**

Prior (2011) and Iyengar (2011) acknowledged that rising raw materials costs along with other factors such as oil, gas and energy are the key causes of increases in the prices of building materials such as cement, roofing membranes and water proofing.

- **Inflation**

Inflation is the general upward trend of prices of goods and services within an economy, it is essentially a measure of how the prices of goods and services increase over time (Fichtner, 2011). The principle behind inflation and how it affects building material prices according to Rakhra and Wilson (1982) is that there is a time lag between an increase in inflation and the effective resulting increase in building material prices.

- **Crude Oil Prices**

Stats SA (2011) and the BER (2008), noted that the Production Price Index (PPI) of various materials rose together with increasing diesel costs in South Africa. Further, Anderson (2011) noted that the global crude oil price is the main driver behind the volatility of some building materials such as PVC, which is a polymer whose raw production material is crude oil.

- **Exchange Rates**

  The exchange rate between two currencies is the amount for which one currency is exchanged for the other, and is used in determining the strength of one currency to another. The degree to which building material prices are affected by exchange rate movements depend on the types and quantities of materials being imported by a country at a specific time, the need to import the raw materials used in the production of building materials locally, and on whether local materials (such as copper, timber and steel) are internationally traded commodities (Busreport, 2006; Mohamed, 2006; and Anderson, 2011).

- **Import Duties**

  Import duties are a charge on goods and products brought into South Africa and are put in place to protect local producers from clients trying to outsource cheaper goods from abroad (National Treasury of South Africa, 2008). Import duties on materials have been noted to affect the construction industry and building material prices in countries such as Malaysia, India, Uganda, Kenya and Oman (Editor, 2007; Al-Shaibany, 2008; Odhiambo, 2008; Master Builders Association of Malaysia (MBAM), 2011; Hamsawi, 2011).

4. Concept of the study

The concept that underpins the study is shown in Figure 2.

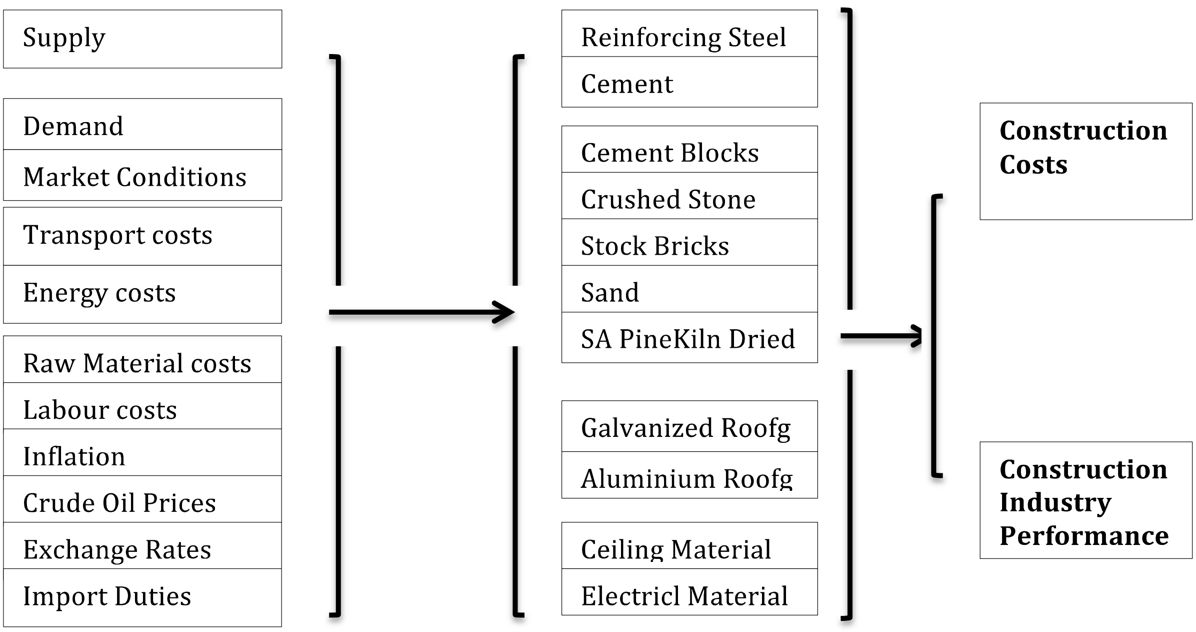

Figure 2: Conceptual Model of the Factors Affecting Building Material Prices

The conceptual model in Figure 2 shows the interrelationships between the economic factors identified in literature, the increasing levels in prices of selected volatile building materials and its resultant effect on construction costs and industry performance. The concept of the study is hinged on the basis that the increasing levels in the prices of building materials can be determined by factors such as energy costs, inflation, raw materials and input costs, transport costs, import duties, demand, supply, exchange rates, crude oil prices and market conditions. The model presupposes that increase in the prices of volatile building materials such as cement, steel, timber, copper, masonry, PVC, bitumen, aggregates and so forth, will invariably lead to an increase in construction costs and affect the performance of the construction industry.

The study will therefore test a proposition that there are key factors perceived by construction industry stakeholders to affect the prices of building materials and that these factors can be benchmarked to actual economic indicators using statistical analysis. The study will also test the hypothesis that there are differences in the key factors perceived by built environment stakeholders to affect the prices of building materials based on their various profiles. That is,

Ho (Null Hypothesis): $U_1 = U_2 = U_3$;
Ha (Alternative Hypothesis): U_1, U_2, U_3 are not equal.

5. Research Method

The detail of the research problem is to examine whether there are differences in the perception held by different construction industry stakeholders of factors that affect building material prices based on their profile. The study made use of the survey approach in which information not available from other sources may be obtained, probability sampling may be executed, and where an unbiased representation of population may be realized. A questionnaire was thus used for this purpose. The questions were structured to elicit information about the background profile of the respondents presented in Table 3, information regarding the perspectives of the respondents of the factors that contribute to building material price increases was sought using a five point Likert scale (Table 2 and Table 3). Secondary data was obtained from three documented sources – BER Index, dti and Stats SA records. The index information was taken and not the real price information due to the fact that the index information is comparable and more accurate (the indices take into account a number of different rates and prices from suppliers and average them out to reach an index amount).

The survey population was construction industry specific focusing on contractors, quantity surveyors and building material suppliers. These three disciplines deal with building material prices within the industry, which will therefore imply accurate, reliable and valid responses. A population of 382 built environment stakeholders, was randomly selected from a list of cidb Registered Contractors, Quantity Surveyors and Building Material Suppliers, in order to obtain the required response rate and sample size, which is statistically acceptable. According to Ott and Longnecker (2001), the central limit theorem holds true when the sample size is equal to or greater than 30, and when other assumptions are also met. Table 1 shows the number of survey sent out between July and August 2011 (a six-week period), using the SurveyMonkey© web based survey tool and the response rate.

Table 1: Number Of Surveys Sent To Sectors Of The Construction Industry

	Contractors	*Quantity Surveyors*	*Material Suppliers*	*Total*
Number Sent	*249*	*101*	*32*	*382*
Responses	*36*	*11*	*6*	*53*
Response rate	*14.5%*	*10.9%*	*18.8%*	*13.9%*

It can be seen from Table 1 that the study achieved an overall response rate of 13.9%. The highest response rate was obtained from the building material suppliers cohort. The combined response from the three groups within the South African construction industry eliminates any bias of opinion that would have emanated, if responses had been taken from one group.

The data obtained was analyzed using descriptive and inferential statistics. A mean item score (MIS) was used to calculate the mean results of the responses on a 5-point Likert scale. The results of the MIS score will present itself as a number ranging between 0 and 1. The ranges shown in Table 2 depict the specific measurements used in the Likert scale and in the interpretation of the MIS score.

Table 2: Mean Item Score (MIS) Grading Table (5 Scale)

Measurement	*Score*
No Impact (M1)	*0 to 0.19*
Low (M2)	*0.20 to 0.39*
Medium (M3)	*0.40 to 0.59*
High (M4)	*0.60 to 0.79*
Very High (M5)	*0.80 to 1.00*

The formula used for the computation of the MIS score is as follows:

$$\mu = \frac{(5\times M5)+(4\times M4)+(3\times M3)+(2\times M2)+(1\times M1)}{5(M5+M4+M3+M2+M1)}$$

6. Data Presentation and Analysis

The data collected from survey responses related to both the stakeholders' perception of factors contributing to the trends in building materials prices and what are the key volatile building materials. The results of the survey and data analysis performed are presented in this section.

6.1 Background Profile of Respondents

Table 3 presents the distribution of the stakeholder's rank of factors perceived to affect building material prices, according to their company, position in the company and years of experience.

Table 3: Distribution of Respondents Rank of Factors Perceived to affect Building Material Prices by Type of Company, Position in Company and Years of Experience

Profile	***Rank of Factors (MIS Scores)***											
	Transport Costs	*Crude Oil Prices*	*Labour Costs*	*Energy Costs*	*Inflation*	*Raw Material Cost*	*Demand*	*Supply*	*Manufacturer's Profit*	*Market Condition*	*Exchange rate*	*Import Duties*
Rank (All Respondents)	*1 (0.86)*	*2 (0.80)*	*3 (0.79)*	*4 (0.76)*	*4 (0.76)*	*6 (0.75)*	*7 (0.71)*	*7 (0.71)*	*9 (0.64)*	*10 (0.62)*	*11 (0.60)*	*12 (0.57)*
Type of Company (N = 52)												
Contractor (69.2%)	*1 (0.86)*	*2 (0.81)*	*3 (0.79)*	*6 (0.75)*	*5 (0.76)*	*4 (0.78)*	*8 (0.68)*	*7 (0.71)*	*10 (0.62)*	*9 (0.65)*	*12 (0.59)*	*11 (0.61)*
Quantity Surveyor (21.2%)	*1 (0.84)*	*5 (0.75)*	*3 (0.76)*	*6 (0.73)*	*3 (0.76)*	*9 (0.65)*	*2 (0.78)*	*7 (0.72)*	*8 (0.69)*	*10 (0.62)*	*11 (0.58)*	*12 (0.52)*
Material Supplier (11.5%)	*1 (0.93)*	*3 (0.83)*	*4 (0.84)*	*2 (0.87)*	*7 (0.73)*	*6 (0.76)*	*5 (0.77)*	*8 (0.72)*	*10 (0.67)*	*12 (0.44)*	*9 (0.70)*	*11 (0.47)*
Position in the Company (N = 51)												
Owner (25.5%)	*1 (0.92)*	*4 (0.80)*	*3 (0.82)*	*7 (0.74)*	*2 (0.87)*	*5 (0.77)*	*9 (0.72)*	*8 (0.73)*	*6 (0.77)*	*10 (0.68)*	*11 (0.63)*	*11 (0.63)*
Director (51%)	*1 (0.83)*	*3 (0.76)*	*2 (0.80)*	*6 (0.74)*	*3 (0.76)*	*3 (0.76)*	*7 (0.72)*	*8 (0.70)*	*10 (0.63)*	*9 (0.64)*	*12 (0.60)*	*11 (0.62)*
Management Staff (25.5%)	*1 (0.88)*	*2 (0.83)*	*4 (0.74)*	*3 (0.80)*	*8 (0.64)*	*4 (0.74)*	*7 (0.68)*	*6 (0.70)*	*11 (0.52)*	*9 (0.58)*	*10 (0.55)*	*12 (0.40)*
Technical Staff (3.9%)	*3 (0.80)*	*1 (0.93)*	*3 (0.80)*	*2 (0.86)*	*3 (0.80)*	*8 (0.67)*	*8 (0.67)*	*6 (0.73)*	*8 (0.67)*	*12 (0.40)*	*7 (0.70)*	*11 (0.60)*
Years of Experience in the Construction Industry (N = 52)												
Less than 10 years (15.4%)	*2 (0.88)*	*1 (0.90)*	*5 (0.80)*	*2 (0.88)*	*4 (0.87)*	*7 (0.73)*	*10 (0.66)*	*8 (0.69)*	*12 (0.58)*	*11 (0.60)*	*6 (0.76)*	*9 (0.68)*
B/w 10 & 20 years (36.5%)	*1 (0.91)*	*3 (0.81)*	*2 (0.83)*	*5 (0.77)*	*7 (0.76)*	*4 (0.79)*	*8 (0.73)*	*5 (0.77)*	*9 (0.68)*	*9 (0.68)*	*11 (0.61)*	*12 (0.60)*
More than 20 years (48.1%)	*1 (0.83)*	*2 (0.75)*	*2 (0.75)*	*6 (0.72)*	*4 (0.73)*	*4 (0.73)*	*7 (0.70)*	*8 (0.68)*	*9 (0.63)*	*10 (0.58)*	*11 (0.56)*	*11 (0.54)*

Table 3 shows that 69.2% of the respondents are contractors, 21.2% are quantity surveyors and 11.5% are material suppliers. Owners, directors and management staff completed the majority of the surveys, with 51% of the respondents being in the directorial cadre of their companies. Table 3 also reveals that built environment stakeholders with over 20 years' experience answered more than 45% of the survey questionnaire and that more than 80% of the respondents have a minimum of 10 years experience. It can be inferred from Table 3 that the data collected from these cohort of respondents will provide reliable and valid information due to the sector of the construction industry in which they come from, position held in the company and number of years of work experience.

It also emerged from the data presented in Table 3 that all the factors identified in literature were perceived by the respondents to have an influence on the prices of building materials but to varying degrees. The key factors perceived by all the respondents to affect building material price increases are transport costs and crude oil prices with MIS scores of 0.86 and 0.80 respectively. Labour costs also emerged as the third key factor, with an MIS score of 0.79. Import duties were perceived to have the lowest impact with an MIS score of 0.57.

Further analysis of the results obtained in Table 3 using the Kruskal-Wallis k-test method of inferential analysis, to test the hypothesis that the perceptions of the respondents differ based on profile revealed that:

- The calculated k value (91.30) is higher than the significant level of 0.05 of the χ^2 tabulated value (5.991) when the results are tested for difference in perception based on position held in the company. Hence, the test result is significant and the alternative hypothesis is accepted that there is a significant difference in the respondents perception of the key factors affecting the prices of building materials based on their position (owner, director or management staff) in the company. The results for the technical staff were excluded from the analysis because the sample size obtained was less than five (Levin and Rubin, 1990).

- The calculated values of k (-2.72 and 3.06) are less than the tabulated value of χ^2 (5.991) for perceptions based on the type of company and the respondents' years of experience in the construction industry respectively. Therefore, the samples' lie within the acceptance region and the test result is not significant. Therefore, the null hypothesis is accepted that there is no difference in the perception of the respondents with regards to the key factors contributing to building material prices based on the type of company in which the respondent works, or based on the respondents' years of experience in the construction industry.

6.2 Respondents' Perception of Building Materials with Volatile Prices

The MIS scores of the perception held by respondents regarding the building material with volatile prices are presented in Table 4.

Table 4 shows that the building materials perceived by the respondents to have volatile prices are steel, copper, cement and bitumen in the order of volatility. When the respondents' perceptions are benchmarked to the actual price increases analyzed in Section 2, it emerged that steel, copper and cement, in order of volatility, which are perceived to be the high ranking volatile building materials, is comparable to the actual and that the stakeholders' have an accurate knowledge of the volatile building materials in the construction industry.

Table 4: Perception of Building Materials with Volatile Prices

Building Material	***Scale***			***Total Response***	***MIS Score***	***Rank***
	Highly Volatile (3)	*Volatile (2)*	*Not Volatile (1)*			
Steel	*36*	*14*	*1*	*51*	*0.90*	*1*
Copper	*23*	*21*	*4*	*48*	*0.80*	*2*
Cement	*21*	*21*	*9*	*51*	*0.75*	*3*
Bitumen	*14*	*28*	*8*	*50*	*0.71*	*4*
Lumber	*7*	*24*	*17*	*48*	*0.60*	*5*
Masonry Bricks/Blocks	*6*	*22*	*21*	*49*	*0.56*	*6*
Sand	*3*	*25*	*22*	*50*	*0.54*	*7*

6.3 Benchmarking Respondents Perceptions against the actual

The study sought to benchmark the respondents' perception against actual economic indicators that may affect future building material prices. The correlation coefficients computed for the economic indices between 2001 and 2011 fourth quarter and the building material price index (BMP), are presented in Table 5.

Table 5: Rank of Correlation Coefficients and Respondents' Perception

Economic Indicators	***Correlation Coefficients***	***Level of Significance***	***Rank based on Correlation Coefficients***	***Rank based on Perception (Table 3)***
Labour Cost	*0.980***	*S*	*1*	*3*
Inflation	*0.973***	*S*	*2*	*4*
Transport Cost	*0.963***	*S*	*3*	*1*
Electricity	*0.850***	*S*	*4*	*4*
Supply	*0.805***	*S*	*5*	*7*
Energy Cost	*0.758***	*S*	*6*	*4*
Oil Index	*0.743***	*S*	*7*	*2*
Demand	*0.159*	*NS*	*8*	*7*
Exchange Rate	*0.112*	*NS*	*9*	*11*

** Correlation is significant at the 0.01 level (2-tailed)
S = Significant
NS = Not Significant
Spearman's Rho (2-tailed) = 0.570 (Not Significant)

Table 5 reveals that Labour cost had the highest correlation with building material prices, followed by inflation and transport cost. Further analysis of the data presented in Table 5, using the Spearman Rank Correlation analysis established that the calculated Rho value of 0.570 in the two-tailed test between the rank based on correlation coefficients computed using actual economic indicators, and the rank based on MIS scores computed from the perception survey, is not significant. The null hypothesis (Ho) is therefore accepted that there are no significant differences in the ranking of the actual and perceived factors that affect the prices of building materials. Based on these findings, it can be concluded that built environment stakeholders have an accurate knowledge and are aware of the factors that affect the prices of building materials and also knowledge of the materials, which are volatile.

7. Discussion of Findings

It emerged from the examination of the prices of building materials between 1992-2011 (a twenty year period) that there has been a definite increase of between 126% and 383% in the prices of building materials, and that reinforcing steel, copper and cement which were at the top of the spectrum experienced rapid changes and significant increase in prices within the last five years (2007-2011). Further, the study established that the respondents perceived the top three volatile building materials to be steel, copper and cement in order of volatility. It therefore appears that the respondents' examined have an accurate knowledge of volatile building materials.

It also emerged from the study undertaken that the key factor perceived by the respondents to cause increases in building material prices is transportation followed by crude oil prices, while market conditions, manufacturers' profiting, exchange rates and import duties were perceived to be of lower impact. However, further interrogation of the data suggests that there are differences in the perception held by the built environment stakeholders, based on their respective position in the company. Suggesting that company owners, directors and management staff in the construction industry, have differing opinions of the factors that affect price increases in the construction industry. That is, the factor considered to have very high impact on building material prices by the company owner is not viewed in the same category by the directors and managers, and vice versa.

The study also established that there are no differences in the opinions held by the respondents of the factors perceived to affect building material prices based on the type of company in which they work or on their years of experience in the construction industry. Implying that the respondents' perceptions could not be differentiated on the basis of the company in which they work or, on their years of experience.

The study findings established that there is a correlation between the factors perceived by the built environment stakeholders to affect building material prices and the actual economic indicators determined by statistical analysis. Implying that built environment stakeholders apparently have an accurate knowledge and are also aware of the factors that affect the prices of building materials. It can be inferred from the study findings that the factors that cause the prices of volatile building materials such as steel, copper and cement to rise rapidly are transport costs, crude oil prices, labour and energy costs. The identified materials minus copper are dense and therefore necessitate high freight costs. Also, these materials require and consume a lot of energy during their extraction and manufacturing processes.

8. Conclusions

It can be concluded that the prices of building materials specifically cement, copper and reinforcing steel are increasing rapidly in South Africa and that the built environment stakeholders are aware and are well-informed about the building materials that are subject to volatility, and the factors including transport costs, crude oil prices, labour costs and energy costs that affect building material prices. Suggesting that if the problems of increasing building material prices is going to be solved in the South African construction industry, particular attention has to be paid to factors such as transport costs, crude oil prices, labour costs and energy costs and also to highly volatile building materials such as steel, copper and cement.

In order to provide lasting solutions, and bring about stable building material prices and avoid a scenario of continuous price increases, the following measure is proposed to counter the problems of transportation and rising fuel prices, since transportation costs which include the transportation of raw materials to the factory and of the distribution of the finished products from the factory to the end user, it is recommended that the South African government develops existing infrastructure to include high-speed freight trains and durable highways, which would bring about the raw materials being transported to the factories efficiently and the effective distribution of the finished products to suppliers and end-users.

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Forecasting Construction Cost Index in the United States using Bivariate Vector Error Correction Models

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Abstract

Short- and medium-term variations of ENR (Engineering News Record) Construction Cost Index (CCI) are problematic for cost estimation and bid preparation. Accurate forecasting of CCI can be invaluable for cost estimation and budgeting of capital projects. The purpose of this study is to create appropriate bivariate Vector Error Correction (VEC) models including CCI and proper explanatory variables for forecasting CCI accurately. Three statistical tests (Unit root test, Granger causality test and Johansen's cointegration test) verify the relevance and examine the characteristics of the explanatory variables that are initially selected based on the literature. Based on the results of the statistical tests, appropriate bivariate VEC models are created to forecast CCI. It is shown that CCIs predicted by bivariate VEC models can be more accurate than those predicted by the seasonal autoregressive integrated moving average model that is one of the most-accurate univariate time series models. The proposed model can assist cost engineers and investment planners to prepare more accurate cost estimates and budgets for capital projects.

Keywords: Construction cost index, Bivariate Vector Error Correction models, Forecasting

1. Introduction

Construction Cost Index (CCI), which has been published by Engineering News-Record (ENR) monthly in the United States, has widely been utilized for estimating costs and preparing bids in the United States. ENR defines Construction Cost Index (CCI) as the weighted aggregate of average prices of constant quantities of common labour, standard structural steel, Portland cement and lumber in 20 cities (ENR, 2011). Short- and medium-term variations of CCI are problematic for cost estimation and bid preparation (Ashuri and Lu, 2010). Accurate prediction of CCI can result in preparing accurate bids and prevent under- or over-estimation (Ashuri and Lu, 2010).

The research objective of this paper is to create appropriate bivariate Vector Error Correction (VEC) models for predicting the short- and medium-term movements of CCI. VEC models are multivariate time series models appropriate for modelling cointegrated variables. We propose bivariate VEC models to forecast CCI because these models use the information in two time series (CCI and an explanatory variable) to forecast CCI and they can potentially be more accurate than univariate time series models. Explanatory variables are the variables that can be useful to predict CCI. In the next section, Research Background reviews the current research on CCI forecasting. In Research Method section, the explanatory variables are initially selected using the relevant literature. Statistical tests (Unit root test, Granger causality test and Johansen's cointegration test) are introduced to verify the relevance and to examine the characteristics of explanatory variables. Bivariate VEC models are described at the end of Research Method section. The Results section presents the results of statistical tests and estimation and prediction of the bivariate VEC models. Conclusions are presented in the last section.

2. Research background

Although much research has been devoted to forecast Tender Price Index (TPI) in Singapore, the United Kingdom and Hong Kong (Taylor and Bowen, 1987; Runenson, 1988; Fellows, 1988; Ng et al., 2000; Wong and NG, 2010), the research regarding the CCI forecasting is rare. In contrast to CCI, TPI is an output measure and can be defined as the average price that clients and/or owners need to pay to build a facility (Ng et al., 2000; Wong and Ng, 2010).

Williams (1994) develops neural network models for forecasting ENR CCI for one month and six months ahead. The trends in CCI, prime lending rate, housing starts, and the months of the year are used as the inputs of the back-propagation neural network models. He concludes that CCI cannot be accurately predicted by the developed neural network models and additional research is needed to identify variables for the development of meaningful and predictive models for CCI. In a recent study, Ashuri and Lu (2010) create univariate time series models to forecast CCI. They conclude that seasonal autoregressive integrated moving average model and Holt-Winters model are the most-accurate univariate time series approaches for forecasting CCI. We depart from the literature and propose bivariate VEC models to forecast CCI. Our hypothesis is that these models can potentially forecast CCI more accurately because they take advantage of the historical information in two time series to forecast CCI.

3. Research method

A group of explanatory variables of CCI are selected based on literature review and data availability. Three statistical tests (Unit root test, Granger causality test and Johansen's cointegration test) verify the relevance and examine the characteristics of the explanatory variables. The consistent explanatory variables will be further used to create bivariate VEC models for predicting CCI.

3.1 Explanatory variables

The explanatory variables of CCI are initially selected by reviewing the relevant literature regarding the explanatory variables of CCI and Tender Price Index. Taylor and Bowen (1987) find building price indices demand-determined. A positive relationship between the construction demand (represented by new orders) and price level is identified by Skitmore (1987). Runeson (1988) concludes that movements in building prices are due to changes in input prices and changes in prices driven by market conditions. He uses three independent variables (building approvals, fixed capital formation in buildings, and unemployment rate) to represent market conditions. Fellows (1988) suggests that interest rates, investment intentions, architect's new commissions, production drawings, enquiries, orders, expected volume of work, and building cost be the leading indicators of the construction price in the U.K. Akintoye et al. (1998) find unemployment level, construction output, industrial production, and the ratio of price to cost indices in manufacturing as the consistent leading indicators of TPI. Ng et al. (2000) use the pattern of changes in eight economic leading indicators (best lending rate, building cost index, consumer price index, gross domestic product, gross domestic product of construction industry, implicit gross domestic product deflation, money supply, and employment rate) for predicting the direction of changes in the Hong Kong TPI. Finally, Wong and NG (2010) conclude that building cost index, Gross Domestic Product, and Gross Domestic Product in construction have explanatory value for predicting TPI.

We initially choose eight explanatory variables based on the literature review and availability. These eight explanatory variables are Consumer Price Index (CPI), Employment Level in Construction (ELC), Building Permits (BP), Housing Starts (HS), Money Supply (MS), Producer Price Index (PPI), Gross Domestic Product (GDP), and Crude Oil Price (COP). Consumer price index, employment level in construction and producer price index are collected form U.S. Bureau of Labor Statistics. Building permits and housing starts are collected from U.S. Bureau of Census. Money supply is retrieved from Board of Governments of the Federal Reserve Systems. Gross domestic product is collected from U.S. Bureau of Economic Analysis and crude oil price is retrieved from U.S. energy information administration. We use the ENR monthly CCI data from January 1975 to December 2010 as CCI time series data in our empirical study. All the explanatory variables are also available from January 1975 to December 2010.

3.2 Statistical tests

Three standard time series tests are used to verify the selection and examine the characteristics of explanatory variables: Unit root test for examining stationarity, Granger causality test for verifying that the explanatory variables are useful to predict CCI and Johansen cointegration test for identifying the cointegrating relationships in the vectors of CCI and the explanatory variables.

Unit root test is used for identifying the integrated order of the variables. The number of times that a time series needs to be differenced for being transformed to stationary time series is the time series' order of integration. Statistical properties of stationary time series do not change after being time-shifted (Brockwell and Davis, 2002). Augmented Dickey-Fuller (ADF) test proposed by Dickey and Fuller (1979) and extended by Said and Dickey (1984) is used for the identification of the order of integration of the explanatory variables. The null hypothesis of the unit root test is that the time series under study is not stationary and the alternative hypothesis is that the time series under study is stationary. The critical values proposed by Banerjee et al. (1993) are used for the rejection of the null hypothesis.

Granger causality test is a statistical hypothesis test to identify whether a time series of a variable is useful to predict the time series of another variable (Granger 1969). The null hypothesis of the test is that the past p values of X do not help the predictability of Y. p is called lag length of the test. The rejection of the null hypothesis means that the past p values of X can be helpful to predict the values of Y. The results of Granger Causality test depend on the chosen lag length (p). Since the Granger causality test is sensitive to the number of lag lengths, it is applied for 6, 12, 18 and 24 lag lengths to examine whether the explanatory variables Granger cause CCI. These lag lengths represent a 2-year time horizon. A variable is explanatory if the null hypothesis is rejected in at least one of the specified lag lengths. The variable is a consistent explanatory variable if the null hypothesis is rejected at all the specified lag lengths. Granger causality test is only meaningful for the stationary time series. In case that a variable is not stationary, it is differenced and the differenced time series is used in this test.

Cointegration test is used to examine if the variables are cointegrated. Variables need to be cointegrated to be used within the VEC models (Pfaff, 2008). In this paper, a cointegration test proposed by Johansen (1988) and extended by Johansen and Juselius (1990) is used to examine whether CCI is cointegrated with each consistent explanatory variable. The null hypothesis of this test is that r is equal to zero. This test depends on lag length. Akaike Information Criterion (AIC) is used to specify the lag length in the cointegration analysis (Akaike 1974). The long-run form of cointegration test and existence of a constant are assumed in the Johansen cointegration test.

3.3 Bivariate Vector Error Correction (VEC) models

Bivariate Vector Error Correction (VEC) models are recommended for time series modelling where two variables are cointegrated (Pfaff, 2008). The long-run form of bivariate VEC models can be defined by the following equation:

$$\Delta y_t = \sum_{i=1}^{p-1} A_i \Delta y_{t-i} + B y_{t-p} + C + \varepsilon_t \qquad (1)$$

where y_t is the (2×1) vector of time series at period t, A_i (i=1,…,p-1) are (2×2) coefficient matrices of endogenous variables, B is (2×2) coefficient matrix containing the cumulative long-run impacts, C is (2×1) vector of constants, and ε_t is (2×1) vector of error terms. The cointegration test also uses the same equation used for representing the bivariate VEC models. Gaussian maximum likelihood (ML) procedure (Johansen, 1995) is used to estimate the coefficients of bivariate VEC models.

4. Empirical results

All the data from January 1975 to December 2010 is used for the statistical tests. Bivariate VEC models are created and estimated using training data from January 1975 to December 2008. Testing data from January 2009 to December 2010 is compared with the forecasts of time series. The predictabilities of bivariate VEC models are compared with the predictability of seasonal autoregressive integrated moving average model proposed by Ashuri and Lu (2010) as one of the most accurate univariate time series models.

4.1 Statistical tests

The integrated orders of CCI and the explanatory variables are determined using ADF unit root tests. The results of ADF unit root tests are presented in Table 1 for CCI and the explanatory variables. Table 1 shows that all the explanatory variables and CCI are not stationary at the level (i.e. they are not stationary before they are differenced). All the explanatory variables and CCI become stationary by applying the differencing operator once. Therefore, based on definition, all the explanatory variables and CCI are integrated of order 1.

Table 1: Results of ADF unit root tests for CCI and the explanatory variables

Explanatory Variables	*ADF t-statistics*	*Explanatory Variables*	*ADF t-statistics*
CCI	*0.34[6]*	*ΔCCI*	*-12.25*[1]*
CPI	*-1.9[6]*	*ΔCPI*	*-5.33*[10]*
ELC	*-2.38[7]*	*ΔELC*	*-3.89*[6]*
BP	*-0.67[10]*	*ΔBP*	*-11.99*[10]*
MS	*0.61[10]*	*ΔMS*	*-4.32*[9]*
COP	*-2.03[7]*	*ΔCOP*	*-8.73*[6]*
PPI	*-1.86[8]*	*ΔPPI*	*-6.50*[7]*
HS	*-0.64[10]*	*ΔHS*	*-11.86*[10]*
GDP	*-1.84[10]*	*ΔGDP*	*-5.09*[10]*

*Notes: Δ is the first difference operator; * Rejection of the null hypothesis at the 1% significance level; [.] denotes the lag length selected based on the AIC criterion (Akaike 1974)*

Table 2 summarizes the results of Granger causality tests between CCI and the initially selected explanatory variables in various lag lengths. The results show that consumer price index, crude oil price, and producer price index consistently Granger cause CCI at all specified lag lengths. Building permits, housing starts, employment level in construction, money supply and GDP Granger cause CCI in only some specified lag lengths. We use only consistent explanatory variables to create bivariate VEC models.

Table 2: Results of Granger causality test between CCI and the explanatory variables

Null hypothesis	*F Statistics*			
	Lag 6	*Lag 12*	*Lag 18*	*Lag 24*
ΔCPI does not Granger cause ΔCCI	*5.71***	*3.47***	*2.79***	*2.63***
ΔELC does not Granger cause ΔCCI	*1.52*	*2.43***	*2.88***	*2.35***
ΔBP does not Granger cause ΔCCI	*3.93***	*2.13**	*1.51*	*1.21*
ΔMS does not Granger cause ΔCCI	*0.77*	*1.14*	*2.15***	*2.61***
ΔCOP does not Granger cause ΔCCI	*4.22***	*3.99***	*3.37***	*2.54***
ΔPPI does not Granger cause ΔCCI	*3.64***	*2.75***	*2.47***	*1.99***
ΔHS does not Granger cause ΔCCI	*4.54***	*2.32***	*1.64**	*1.34*
ΔGDP does not Granger cause ΔCCI	*1.75*	*1.71*	*1.69**	*1.54**

*Note: Δ is the first difference operator; * Rejection of the null hypothesis at the 5% significance level; ** Rejection of the null hypothesis at the 1% significance level;*

The results of Johansen's cointegration test for the bivariate vectors of CCI and the consistent explanatory variables are presented in Table 3. The trace statistics show that null hypothesis of no cointegrating relationships between CCI and the consistent explanatory variables (*r=0)* can be rejected at 1% significant level for (CCI and consumer price index), (CCI and crude oil price) and (CCI and producer price index). Therefore, CCI and each consistent explanatory variable are cointegrated at the 1% significance level.

Table 3: Results of the Johansen cointegration tests

		Trace statistics	
Explanatory Variables	*Lag length*	*(H0: r=0)*	*(H0: r≤1)*
CCI & CPI	*7*	*41.57**	*3.02*
CCI & COP	*6*	*64.86**	*6.65*
CCI & PPI	*6*	*53.81**	*6.60*

Note: Rejection of the null hypothesis at the 1% significance level; the critical values that are proposed by Osterwald-lenum (1992) are used for the rejection of the null hypothesis;*

4.2 Bivariate Vector Error Correction (VEC) models

Based on the results of statistical tests, three bivariate VEC models are created. The first VEC model is a bivariate VEC model including CCI and producer price index. The second VEC model is a bivariate VEC model including CCI and consumer price index. The third VEC model is a bivariate VEC model including CCI and crude oil price. The coefficients of these VEC models are estimated.

The residuals of the VEC models should not have serial correlation and their variance should be constant (Lack of heteroskedasticity). Existence of serial correlation among the residuals of the VEC models is diagnosed using Breusch-Godfrey LM test proposed by Breusch (1978) and Godfrey (1978). ARCH test (Engle 1982) is applied for investigating heteroskedasticity in the residuals of CCI in the VEC models. Table 4 summarizes the results of Breusch-Godfrey LM test on the residuals of the VEC models. It also shows the results of ARCH test on the residuals of CCI in the VEC models. The null hypothesis of Breusch-Godfrey LM test is that there is no serial correlation in the residuals. Constant variance of the residuals is the null hypothesis of ARCH test.

Table 4: Results of Breusch-Godfrey LM and ARCH tests for the residuals

Models	*Breusch-Godfrey test statistics*	*ARCH statistics*
$VECM_1$	*36.0*	*18.5***
$VECM_2$	*42.52**	*16.2**
$VECM_3$	*30.3*	*11.8*

Notes: Rejection of the null hypothesis at the 5% significance level; ** Rejection of the null hypothesis at the 1% significance level; $VECM_1$ represents the model including CCI and producer price index; $VECM_2$ represents the model including CCI and consumer price index; $VECM_3$ represents the model including CCI and crude oil price; The lag length is selected based on the AIC criterion (Akaike 1974).*

The results of Breusch-Godfrey test indicates that the null hypothesis (no serial correlation) cannot be rejected for the VEC model including CCI and producer price index and the VEC model including CCI and crude oil price at 1% significance level. However, the null hypothesis (no serial correlation) can be rejected at 5% significance level for the VEC model including CCI and consumer price index. The results of ARCH test show that the residuals of CCI have constant variance in the VEC model including CCI and crude oil price. However, the null hypothesis of constant variance of the CCI residuals can be rejected at 5% and 1% significance level for the VEC model including CCI and consumer price index and the VEC model including CCI and producer price index, respectively.

4.3 Predictability of the bivariate VEC models

The predictability of the bivariate VEC models are examined through the comparison with seasonal autoregressive integrated moving average model for forecasting CCI. Ashuri and Lu (2010) proposed seasonal autoregressive integrated moving average model as one of the most-accurate univariate time series approaches for forecasting CCI. The predictability of the time series models are compared based on two error measures: Mean Absolute Prediction Error (MAPE) and Mean Squared Error (MSE). Tables 5 presents MAPE and MSE calculated using forecasted data points provided by the models and the testing data from January 2009 to December 2010. The testing data is not used for the estimation of the models. Based on the results shown in Table 5, two bivariate VEC models (the VEC model including CCI and producer price index and the VEC model including CCI and crude oil price) provide better forecasts than seasonal autoregressive integrated moving average model. Among bivariate VEC models, the model including CCI and producer price index provides the best forecasts. In order to put these error measures into context, we provide an example to show the relative dollar differences. Under the assumption that CCI fully represents the construction cost for a \$10 million project, an average 1% error in prediction of CCI for the following years might result in up to 1% error in cost estimation which is \$100000.

Table 5: Forecasting errors of time series models

Error measure	*$VECM_1$*	*$VECM_2$*	*$VECM_3$*	*S-ARIMA*
MAPE	*0.83%*	*1.42%*	*1.04%*	*1.38%*
MSE	*8216.6*	*20046.0*	*13035.5*	*17754.0*

Notes: S-ARIMA represents Seasonal ARIMA, $VECM_1$ represents the VEC model including CCI and producer price index; $VECM_2$ represents the VEC model including CCI and consumer price index; $VECM_3$ represents the VEC model including CCI and crude oil price.

The predictability of the models might have been influenced by unexpected and abrupt changes in CCI or abrupt and unexpected changes in the consistent explanatory variables. Figure 1 displays CCI, producer price index, crude oil price, and consumer price index from January 2000 to December 2010. Among the variables, crude oil price shows a significant change. As it can be seen in Figure 1, there is an abrupt change in crude oil price in 2008. Despite this abrupt change, the model created with CCI and crude oil price has a better predictability than seasonal ARIMA. Since crude oil price experienced a significant and abrupt change, further research is required to show if the predictability of the VEC model including CCI and crude oil price provides a reliable prediction over time.

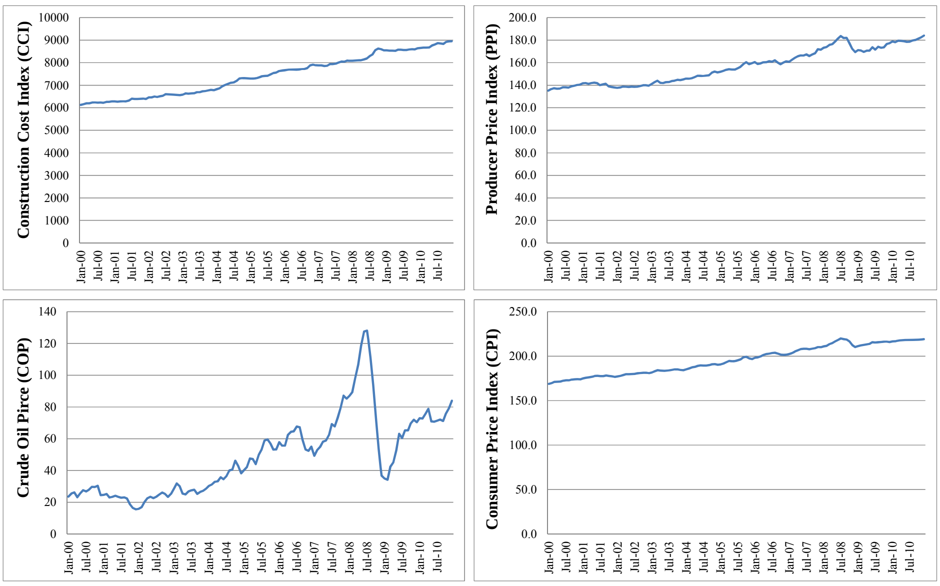

Figure 1: Trends of CCI, producer price index, crude oil price and consumer price index over time

5. Conclusions

Accurate short- to medium-term prediction of CCI can be invaluable for cost estimation and budgeting of capital projects. Bivariate VEC models are created to forecast CCI accurately using the historical information in CCI and the explanatory variables. Consumer price index, employment level in construction, building permits, money supply, crude oil price, producer price index, housing starts, and gross domestic product are initially selected as the explanatory variables for CCI. Statistical tests show that consumer price index, producer price index and crude oil price are the consistent explanatory variables which are cointegrated with CCI.

Three bivariate VEC models are created and the coefficients are estimated. The predictabilities of the bivariate VEC models are compared with seasonal autoregressive integrated moving average model. Two bivariate VEC models (the VEC model including CCI and producer price index and the VEC model including CCI and crude oil price) provide better forecasts than seasonal autoregressive integrated moving average model. Among bivariate VEC models, the model including CCI and producer price index has the best predictability in terms of mean absolute prediction error and mean squared error. The proposed bivariate VEC models can help cost engineers and capital planners prepare more accurate bids, cost estimates, and budgets for capital projects.

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Relationship of construction sector to economic growth

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Abstract

Construction is a major industry throughout the world accounting for a sizeable proportion of most countries' Gross Domestic Product (GDP) and Gross National Product (GNP). The importance of the construction sector is not only related to its size but also to its role in economic growth. An industry sector this big could not but have an impact on the economy. In relation to the importance of the construction sector in both national and world economies, current knowledge of it is poor. As a result, policy-makers may be misguided or even destructive. Economic growth is currently an issue of global concern as most economies are finding it difficult to create the necessary employment opportunities and achieve meaningful growth. This research mobilizes three economic growth theories in trying to explain the relationship between the construction sector and economic growth, namely: Harrod–Domar model, Solow growth model and Endogenous growth model. Central to the research is to ascertain how national governments stimulate economic growth, with a view to enabling policy-makers to make better use of the construction sector. Time series statistical analysis of construction output data for South Africa and the UK was used. This preliminary analysis, which is part of a PhD study, reveals that there is not an obvious link between construction investment and economic growth.

Keywords: Construction economics, economic growth, construction sector

1. Introduction

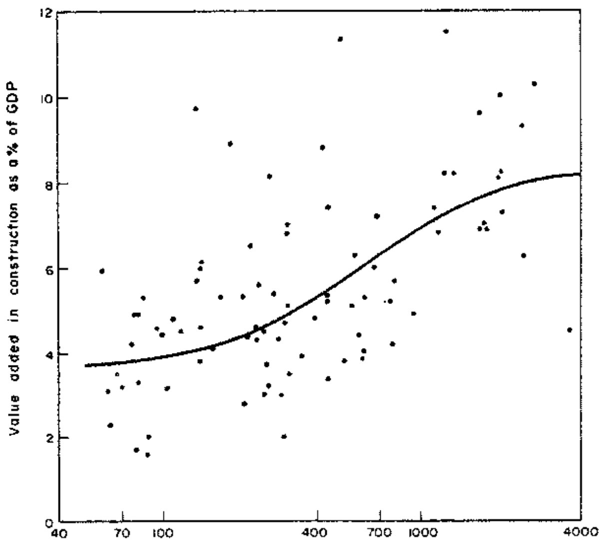
The construction sector is envisaged to play a powerful role in economic growth, in addition to producing structures that add to productivity and quality of life. Since construction is labour-intensive, when the sector is working at full capacity, large sections of the nation's work force are active. Given such characteristics, can the construction sector be used to build our way out of the recession? Apparently not. Econometric analysis of Cape Verde to test whether construction contribute to economic growth, concludes that construction activity follows economic growth (Lopes *et al*. 2011). Therefore the construction sector cannot cause economic growth. What then are the minimum necessary and sufficient conditions for economic growth?

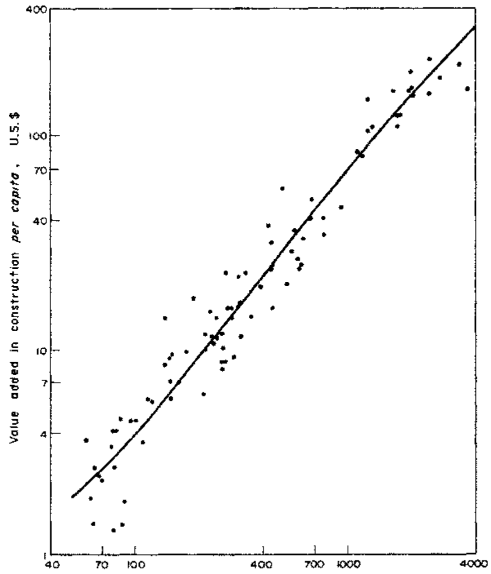
Different standards are used in the categorization or classification of economies. The World Bank classifies economies of countries as low income, middle income (subdivided into lower middle and upper middle), and high income. The main criterion for these is the gross national income (GNI) per capita. Authors such as Tan (2002) use this standard. Another common standard of categorization based on development stage of the country was used mainly by Bon (1992) and Crosthwaite (2000). This standard is based on the perceived changing role of construction as economic development proceeds. It consists of less developed countries (LDCs), newly industrialised countries (NICs) and advanced industrial countries (AICs). The IMF classifies countries as developed or advanced economies and developing or undeveloped countries. The United Nations human development index also uses first world and third world classifications to denote developed and developing countries respectively. Although the criteria used to arrive at all these different classifications remain a contentious issue, they will be used interchangeably throughout this research.

Turok (2008), in his book on the evolution of the African National Congress economic policy, argued that the term developing countries implies that economic growth is the only way forward, while it is not necessarily the most beneficial. He continues to say the term third world implies the false notion that those countries are not a part of the global economic system. It is of interest to note that different writers use different classifications to try and understand the fundamental socio-economic status of the countries they may be dealing with at any given point in time.

2. Literature review

Turin (1978), using time series analysis, examined briefly the place of construction in the world economy, its dynamic relationships with other major development indicators, the main technological problems facing the industry in developing countries and finally a set of broad policy issues. Turin's work is based on his personal experience of construction in developing countries and on the results of research carried out by members of the Building Economics Research Unit (BERU) of the University College London. Turin's sample was composed of 87 countries and spanned 1960-78. His findings on the relationship of construction and economic growth are shown in Figures 1 and 2. The data from each country were plotted in a graph and the line drawn, represented the regression fit.





Per capita GDP, US$

Per capita GDP, US$

Figure 1: S-shaped relationship
(Source: Turin 1978)

Figure 2: Effect on growth
(Source: Turin 1978)

Figure 1 shows that the share of construction grows from 4-8% between US$100-4000 per capita and that the highest rate of increase occurs in the middle range of countries (US$400-1000). Turin hypothesized the relationship to be S-shaped. Figure 2 shows that the value added in construction per capita grows more rapidly than GDP per capita. At both extremes of the range, the slope of the relationship is approximately one. This means that above a certain level of GDP per capita, construction accounts for an approximately fixed share of the national product. Turin (1978) concluded that the share of construction in the national product and the value added in construction per capita grow with economic development. The construction sector exhibits unique features in terms of its significance, which need to be understood for their impact in economic growth. Turin (1978) found that an S-shaped relationship exists, however, the intrinsic nature of the relationship remains unknown.

Bon (1992) discussed the changing role of the construction sector at the various stages of economic development. He studied the construction activity since World War II in Finland, Ireland, Italy, Japan, the UK, and the USA. The data underlying his analysis spans a 50-year period and appears to place special emphasis on Europe. He argued that construction follows the bell-shaped pattern of development or an inverted U-shaped relationship as shown in Figure 3. This assumption is founded on the observation that the share of construction in GNP first grows and then declines with the level of economic development. The inverted U-shaped relationship is associated with less population growth, less migration and the assumption that most physical capital is already in place in later stages of economic development. Of interest to note is that the output data used by Bon excludes housing as well as repairs and maintenance (R&M).

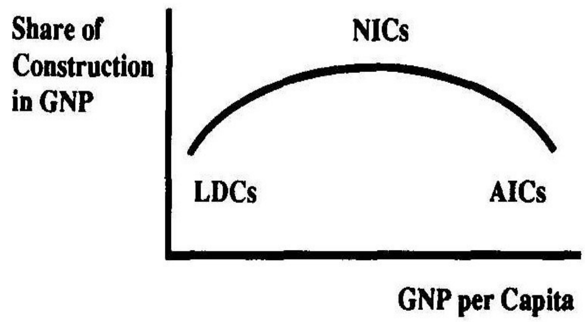


Figure 3: The Bon curve (Source: Bon 1992)

The inverted U-shaped relationship presented by Bon (1992) is very different from the S-shaped relationship found by Turin (1978). Bon argued that the main reason for Turin's S-shaped relationship is that his sample is dominated by less developed countries (LDCs) and newly industrialised countries (NICs), so that the trends characteristic of advanced industrial countries (AICs) were obscured. It may be argued though that Bon's study also gives emphasis on AICs primarily due to the paucity of reliable economic data concerning NICs and LDCs. This therefore presents the need for further holistic study of the relationship between the construction sector and economic growth.

Authors on construction economics such as Jackman (2010), Myers (2008), Hillebrandt (2000), Tan (2002), Bon (1992), Wells (1986) and Turin (1978) all emphasized the importance of the role that the construction sector play in economic growth. However, they seemed to base their work purely on the power of their argument, without reporting any empirical data or observations, and without analysis or questioning of their own ideas. It would appear that writers in this area, generally, start with the assumption that the construction sector drives economic growth. It is very difficult to find anyone who questioned this.

Most governments believe that the construction sector plays a powerful role in economic growth, in addition to producing the structures that add to our productivity and quality of life. Policy-makers assume that the construction sector is a driver for economic growth. The linkages that the construction sector has with other economic sectors are not clear. Why is growth needed?

Economic growth is about stimulating the economy. The government stimulates the economy to achieve economic growth so that this will help create jobs. Increased economic activity requires a corresponding increase in the provision of roads, and other infrastructure. So, a double investment is needed if the jobs created are outside construction. In addition, international trade rules may obstruct direct subsidies to businesses, because that would create unfair market advantage.

Therefore the research question is:

What is the relationship between the construction sector and economic growth?

3. Methodology

Time series statistical analysis of construction output and construction share of GDP for South Africa (SA) have been undertaken to establish the trends and get a handle on the intricate dynamic interrelationships between the construction sector and economic growth. Secondary data on construction output and GDP was sourced initially from electronic archives of Statistics South Africa (SSA). More data was also sourced from national accounts and national economic outlook reports from the South African Reserve Bank (SARB). Collected data ranged from annual, quarterly and monthly output reports illustrating real and nominal figures.

Empirical analysis of the secondary data collected for SA was benchmarked against similar data for the UK, to ensure a balanced analysis. The 2 countries are at different developmental trajectories. The UK is a developed economy and older data was available as opposed to SA where relevant construction data only started to be documented in 1993 by SSA. It would have given a broader picture of the trends if older data was available for SA. The initial aim of the researcher was to look at data covering the last 100 years. Statistical and graphical analysis of the data was undertaken to establish the correlation of construction and economic growth.

4. Research findings

The South African economy, like the political change that took place in South Africa since the release of former state president Dr Nelson Mandela in 1990, had to undergo remarkable growth. The dismantling of apartheid ended years of the country’s isolation and local political instability. The birth of democracy opened up the country to the global economic stage as economic sanctions were lifted, which had a substantial effect not only on the everyday life of the citizens but also on the business and financial investment climate.

4.1 The SA construction sector

The construction sector responded positively to the developments that took place in political circles and in the overall structure of the SA economy. From 1990, there was a steady growth both in total construction output up to 1994 when the first democratic elections took place. This steady increase may be associated with confidence in the overall economy and hope for the country that was generated by Dr Mandela’s release from prison. Figures 4 and 5 illustrate this at constant 2005 prices.

Although no related construction data could be found for the period before 1986, the available data suggest that like other sectors of the SA economy, the construction sector suffered significantly from international isolation in the hands of the apartheid government. Annual change in construction output for the period 1986 to 1988 suggest that the contribution of the construction sector to the economy was declining (see Figure 5).

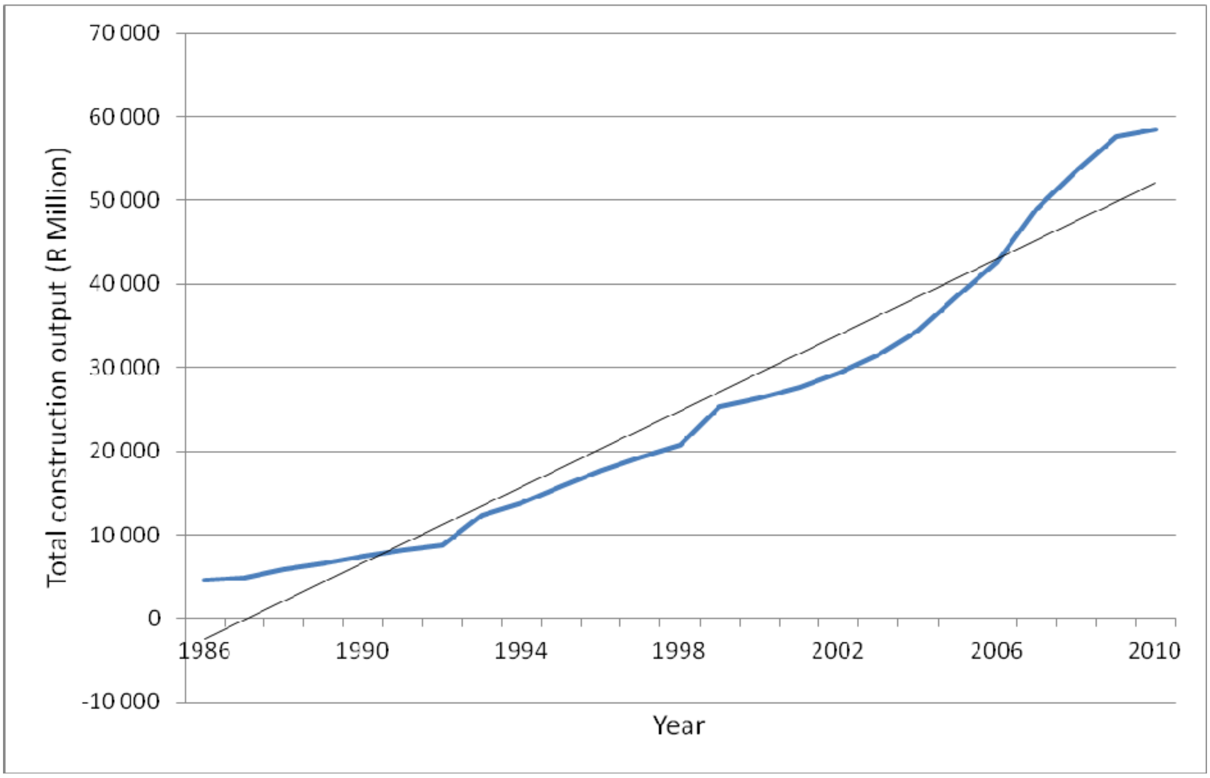


Figure 4: Total construction output 1986-2010
(Data source: Statistics South Africa, 2011)

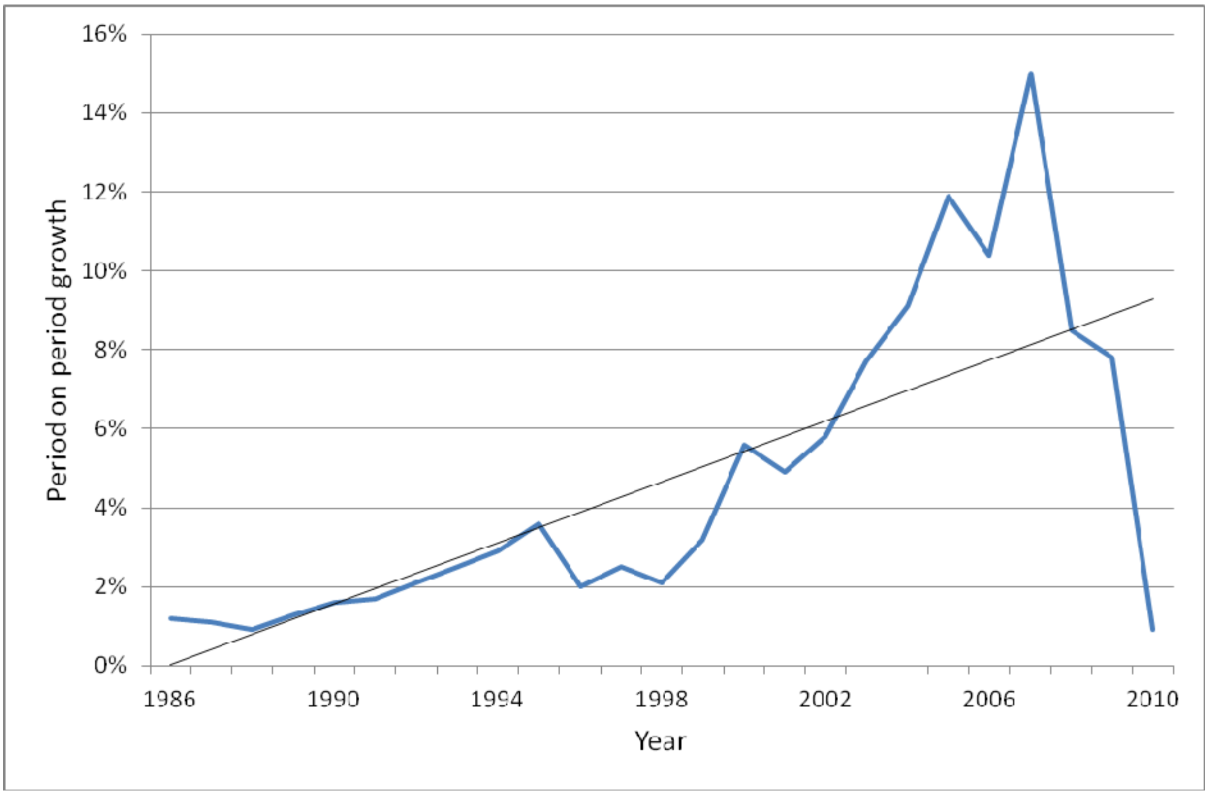


Figure 5: Annual change in construction output, 1986-2010
(Data source: Statistics South Africa, 2011)

The construction sector experienced a steady increase in construction output from 1990 through 1994 to 2010 as shown in Figure 4. From 1989, when former state president FW de Klerk came into power and promised significant political reforms including the release from prison of Dr Nelson Mandela, unbanning of political parties and the repealing of apartheid laws, annual change in construction output started to show signs of growth. The growth trend gained momentum when Dr Mandela was released from prison in 1990 and continued growing until 1994.

After the ANC government came into power in 1994, the annual change in construction output continued to show growth by a further 0.7% in 1995 as the new government started implementing the reconstruction and development programme (RDP). Subsequent to some structural difficulties with the implementation of the RDP, the annual change in construction output plummeted by a whopping 1.6% in 1996 as may be seen in Figure 5. As the RDP office closed down in 1996 and the implementation of RDP projects decentralised to related departments, mainly the Department of Public Works and the Department of Housing, annual change in construction output increased by 0.5% to 2.5%.

This robust growth was temporarily stopped in 1997 and 1998 when overall economic growth dwindled to only 0.5%, as exports and foreign capital inflows decreased due to various international economic movements, for example a drop in the price of gold, the weakness in the United States, European and Japanese economies, the East Asian financial crisis and the delayed effects of the stronger rand in 1997. The SA economy had been recovering quite robustly from the setbacks suffered at the time of the international financial crises of 1997 and 1998 when world economic conditions began to deteriorate towards the end of 2000. Real GDP was growing at an average annualised rate of some 3½% in the second half of 2000, but when weaker international demand conditions began to spill over into SA, economic growth fell back to an annualised rate of about 2½% in the first half of 2001(South African Reserve Bank, 2006).

The sharp decline in annual change in construction output (see Figure 5) that SA experienced from 2008 to 2010 was in part a consequence of the global financial crisis. The SA economy has not reached its maturity yet so it is to be expected that this trough will be reversed as economic recovery strengthens. The rate of economic recovery and the share of construction thereof remains an interesting subject for economists' prediction. Economic recovery in the Euro-zone and the US, as significant trade partners, continues to have major repercussions on the SA economy. During the global economic downturn SA's construction sector managed, on the whole, to avoid some of the worst effects of the crisis, as a result of the many infrastructure projects that were being implemented, including those related to South Africa's hosting of the 2010 FIFA world cup. However, the hangover from the world cup has caused a slump in construction activity.

4.2 The UK construction sector

The data used to generate the graphs presented herewith was sourced from the Office of National Statistics (ONS) website. Figure 6 shows construction output figures at constant 2005 prices, whilst Figure 7 illustrates the annual change in construction output as a percentage.

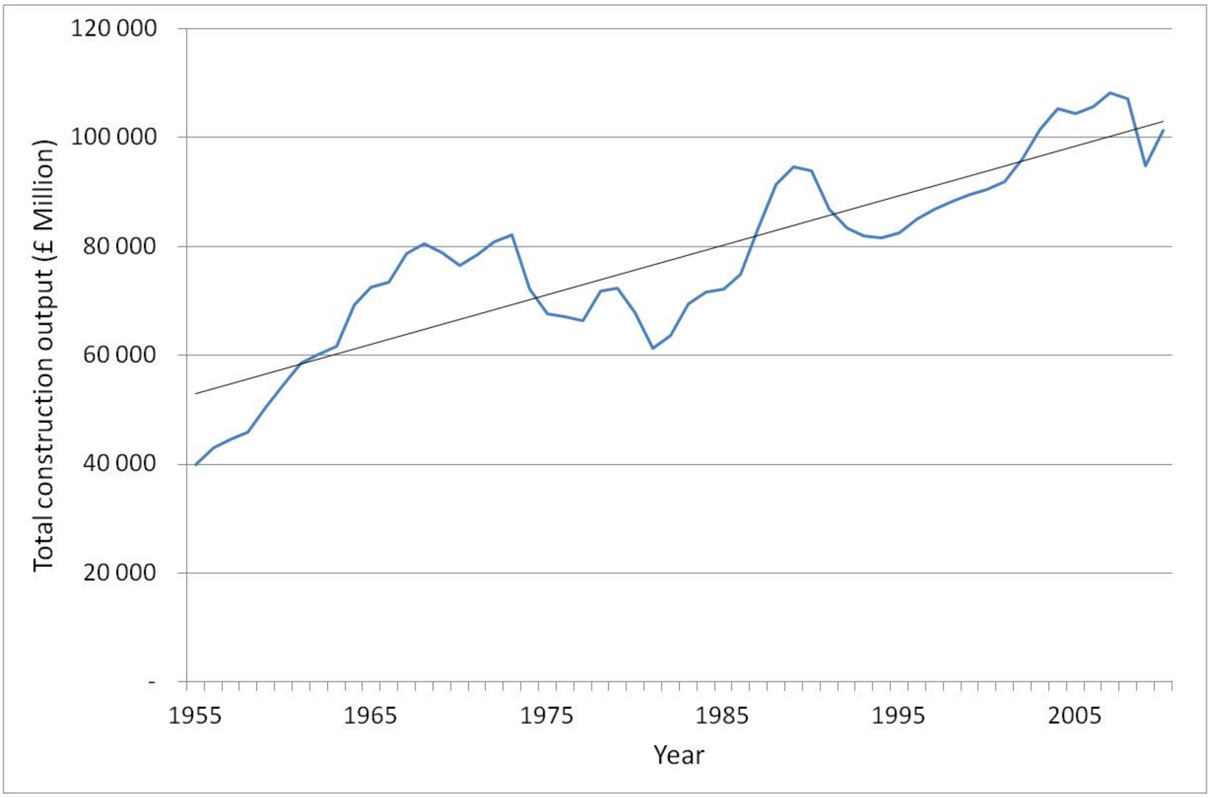


Figure 6: Total construction output, 1955-2010
(Data source: ONS, 2011)

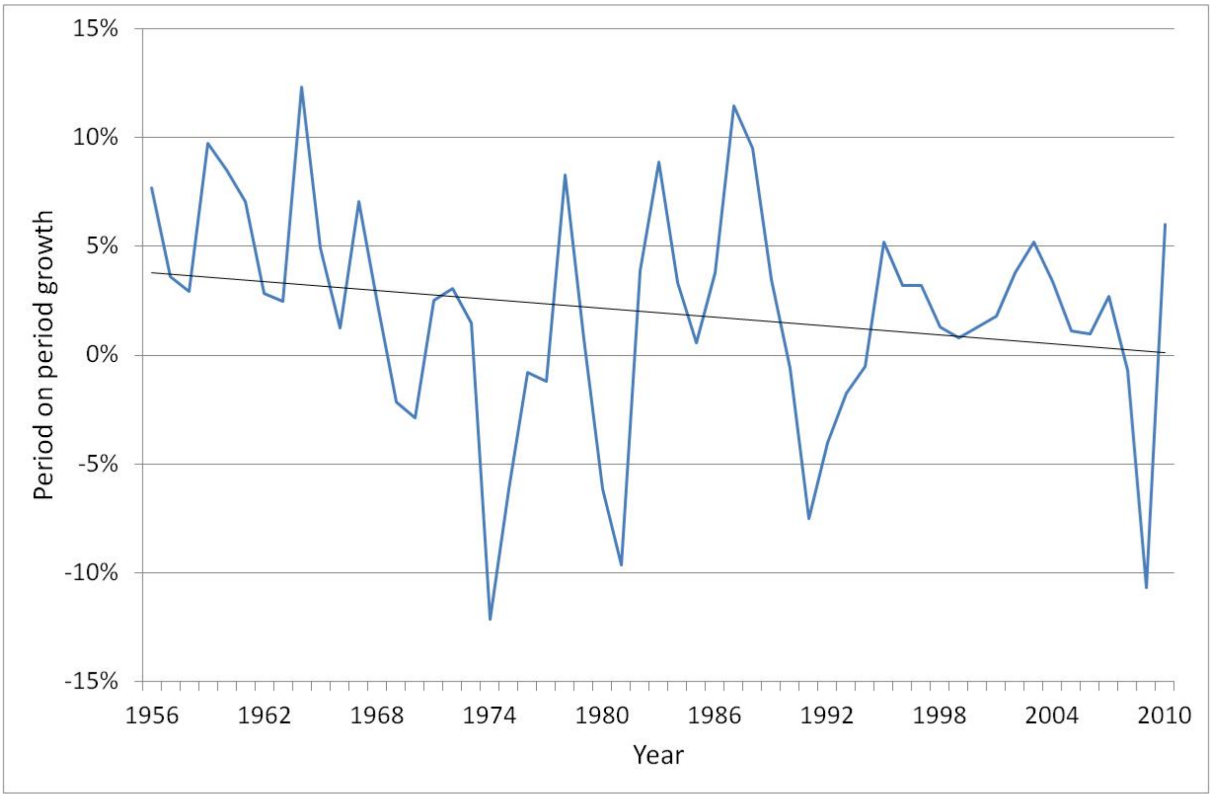


Figure 7: Annual change in construction output, 1956-2010
(Data source: ONS, 2011)

A linear trend line (see Figure 7) across the period under review (1955-2010) reveals a downward spiral of the annual change in construction output. This is in contrast to the upward spiral that can be observed in Figure 5 pertaining to the year on year growth of construction output experienced by SA over the period 1986 to 2010. The two seemingly contradictory trends that emerge here tend to support the view by Bon (1992) that the contribution of construction will increase whilst the economy is developing, and then decline as the economy reaches its maturity. South Africa is still a developing economy hence it is to be expected that the annual change in construction output should go up.

On the other hand, the UK is a developed economy and as such the annual change in construction output is declining. While capital formation in construction is a measure of the gross output of the construction sector, and therefore does include the value of goods and services supplied to the construction industry from other sectors, it unfortunately excludes that which is not considered to accrue to the formation of new capital - which is much of repairs and maintenance work (Wells, 1986). This explains why the UK total construction output is on an upward spiral whilst the annual change in construction output is declining.

5. Analysis and synthesis

Trends in construction output and GDP have been scrutinized to test the existence of a relationship between the construction sector and economic growth. Tables 1 and 2 illustrate the relationships found. Analysis of 3, 5, and 8 year moving averages applied to all variables shows that booms and busts in the economy do not have a significant impact in long-term construction output and economic growth. They actually distort the ‘natural growth’ path.

The correlation coefficient with GDP reveals a very strong relationship between construction output and GDP for both the UK and SA. The correlation coefficient with growth for the UK reveals a weak relationship. The SA data shows that construction output influences growth, as represented by the correlation coefficient that leans more to the positive side.

The contrast in correlation coefficients between Table 1 and 2 confirms the assumption that in the upward growth trend in LDCs and NICs, the pattern of the construction sector tends to follow that of the general economy. The SA data shows that whenever there is growth in the economy, there is also growth of the annual change in construction output (see Figure 5). Wells (1986) also attested to this relationship.

Figure 5 shows a significant increase in the annual change in construction output between 2004 and 2008. This was the time when most of the major infrastructure projects related to the hosting of the 2010 FIFA World Cup started. This demonstrates an association between construction investment and economic growth. It is also important to note that this finding is consistent with economic growth theory, in particular, the endogenous growth models.

The growth in construction output reflected in Figures 4-5 and also in Table 1 indicates that growth in the SA economy was pulling the growth that was experienced by the construction sector particularly

Table 1: Trends in construction output & GDP in SA 1986-2011

Year	GDP (Constant)	Growth (ΔGDP)	Total Constr Output	3yr MA Growth	5yr MA Growth	8yr MA Growth
1986	129 488	0.2	11 718			
1987	464 786	1.6	12 779			
1988	552 516	3.8	15 137	1.87		
1989	644 831	2.2	17 084	2.53		
1990	734 725	-0.6	19 359	1.80	1.44	
1991	830 642	-0.5	21 322	0.37	1.30	
1992	916 403	-2.3	22 924	-1.13	0.52	
1993	1 081 261	1.8	24 892	-0.33	0.12	0.78
1994	1 116 228	3.2	25 611	0.90	0.32	1.15
1995	1 125 139	3.1	26 521	2.70	1.06	1.34
1996	1 173 600	4.3	27 056	3.53	2.02	1.40
1997	1 204 721	2.7	27 987	3.37	3.02	1.46
1998	1 221 086	0.5	26 338	2.50	2.76	1.60
1999	1 249 881	2.4	25 980	1.87	2.60	1.96
2000	1 301 813	4.2	27 448	2.37	2.82	2.78
2001	1 336 962	2.7	28 800	3.10	2.50	2.89
2002	1 386 435	3.7	30 473	3.53	2.70	2.95
2003	1 427 322	2.9	31 575	3.10	3.18	2.93
2004	1 492 330	4.6	34 451	3.73	3.62	2.96
2005	1 571 082	5.3	38 558	4.27	3.84	3.29
2006	1 659 122	5.6	42 582	5.17	4.42	3.93
2007	1 751 165	5.6	48 971	5.50	4.80	4.33
2008	1 814 532	3.6	53 145	4.93	4.94	4.25
2009	1 786 637	-1.5	57 279	2.57	3.72	3.73
2010	1 838 264	2.9	57 781	1.67	3.24	3.63
2011	1 895 668	3.1	58 241	1.50	2.74	3.65
Correlation coefficient with Growth			0.28	0.70	0.51	0.27
Correlation coefficient with GDP			0.93	0.51	0.79	0.93

between 2004 and 2008. Since economic growth leads construction, policy – makers can keep track of the trends in the main stream economy and devise responsive policies that seek to respond to the economic conditions of the time.

Construction influences investment. Economic growth models since Harrod-Domar have shown the importance of investment in determining economic growth. More recently, both the Solow and endogenous growth models continue to attribute an important role to capital formation. It therefore follows that it is likely that construction can influence short-run growth. To test the impact of the construction sector on long-run growth, it is necessary to get more data on labour, capital and R&D statistics covering the periods under review. Due to the unavailability of this data at this stage, it is not possible to test the impact of construction on long-run growth.

Table 2: Trends in construction output & GDP in the UK 1955-2011

Year	GDP (Constant)	Growth (ΔGDP)	Total Constr Output	3yr MA Growth	5yr MA Growth	8yr MA Growth
1955	385 425	4.2	39 934			
1956	389 004	5.6	43 001			
1957	395 426	3.7	44 560	4.50		
1958	396 699	3.1	45 906	4.13		
1959	413 664	1.2	50 349	2.67	3.56	
1960	435 716	1.5	54 649	1.93	3.02	
1961	445 870	2.8	58 515	1.83	2.46	
1962	450 695	3.4	60 150	2.57	2.40	3.19
1963	470 067	2	61 665	2.73	2.18	2.91
1964	495 835	3.6	69 206	3.00	2.66	2.66
1965	506 915	5.5	72 614	3.70	3.46	2.89
1966	516 673	4.1	73 513	4.40	3.72	3.01
1967	529 418	2.6	78 694	4.07	3.56	3.19
1968	551 664	4.6	80 566	3.77	4.08	3.58
1969	563 097	4.2	78 838	3.80	4.20	3.75
1970	575 736	2.7	76 579	3.83	3.64	3.66
1971	587 805	3.7	78 468	3.53	3.56	3.88
1972	609 275	2.9	80 861	3.10	3.62	3.79
1973	653 124	4.6	82 073	3.73	3.62	3.68
1974	644 539	5.3	72 121	4.27	3.84	3.83
1975	640 534	5.6	67 690	5.17	4.42	4.20
1976	657 418	5.6	67 183	5.50	4.80	4.33
1977	673 025	3.6	66 368	4.93	4.94	4.25
1978	694 765	-1.5	71 853	2.57	3.72	3.73
1979	713 380	2.9	72 381	1.67	3.24	3.63
1980	698 528	3.1	67 911	1.50	2.74	3.65
1981	689 289	6.2	61 376	4.07	2.86	3.85
1982	703 711	7.5	63 741	5.60	3.64	4.13
1983	729 215	5.3	69 420	6.33	5.00	4.09
1984	748 691	4.9	71 709	5.90	5.40	4.00
1985	775 643	5.5	72 101	5.23	5.88	4.24
1986	806 765	4.5	74 866	4.97	5.54	4.99
1987	843 572	5.2	83 426	5.07	5.08	5.28
1988	886 020	5.7	91 383	5.13	5.16	5.60
1989	906 236	6.9	94 566	5.93	5.56	5.69
1990	913 299	0.8	94 017	4.47	4.62	4.85
1991	900 580	-1.4	86 930	2.10	3.44	4.01
1992	901 901	0.1	83 443	-0.17	2.42	3.41
1993	921 945	2.2	82 000	0.30	1.72	3.00
1994	961 407	4.3	81 607	2.20	1.20	2.98
1995	990 751	3.1	82 428	3.20	1.66	2.71
1996	1 019 337	2.9	85 067	3.43	2.52	2.36
1997	1 054 232	3.3	86 845	3.10	3.16	1.91
1998	1 094 704	3.6	88 366	3.27	3.44	2.26
1999	1 134 723	3.5	89 535	3.47	3.28	2.88
2000	1 185 305	3.9	90 450	3.67	3.44	3.35
2001	1 222 650	2.5	91 998	3.30	3.36	3.39
2002	1 255 142	2.1	96 146	2.83	3.12	3.11
2003	1 299 381	2.8	101 507	2.47	2.96	3.08
2004	1 337 782	3	105 253	2.63	2.86	3.09
2005	1 365 685	2.2	104 428	2.67	2.52	2.95
2006	1 401 290	2.8	105 753	2.67	2.58	2.85
2007	1 449 861	2.7	108 279	2.57	2.70	2.75
2008	1 433 871	-0.1	107 073	1.80	2.12	2.25
2009	1 371 163	-4.9	94 811	-0.77	0.54	1.33
2010	1 399 850	1.4	101 306	-1.20	0.38	1.24
2011	1 409 015	0.7	107 331	-0.93	-0.04	0.98
Correlation coefficient with Growth			-0.31	0.74	0.56	0.53
Correlation coefficient with GDP			0.90	-0.41	-0.42	-0.48

6. Conclusion

There is evidence of the existence of a very strong relationship between construction activity and economic growth. As an investment sector, construction has the potential to impact positively on short-run growth. Construction can thus be regarded as a major component of investment programmes, particularly for developing economies like South Africa.

It can be concluded that the generally sharp growth in construction share of GDP in the period leading up to the 2010 FIFA World Cup in SA, resulted in a huge demand for additional resources in the form of material, plant and manpower. Whilst these were successfully imported to meet the schedule demands of the 2010 FIFA World Cup infrastructure projects, such a trend could not be sustainable for continuous economic growth hence the sharp decline in construction share of GDP from 15% in 2007 to 1.5% in 2010. The importation of resources may be costly as these have to be paid for in foreign currency. The effect of foreign direct investment in this regard, would need to be explored further.

Construction is an important part of the development and modernisation process. While it is closely correlated with economic growth, it does not follow that providing incentives and increased spending on projects necessarily leads to economic growth. In the Keynesian sense, like in any other sector, increased spending in the construction sector does stimulate economic growth. The construction sector deals mainly with the provision of capital infrastructure, which has an impact on economic growth. The delivery of such infrastructure creates significant employment opportunities for the population, which generates further investment in other sectors of the economy through the multiplier effect.

Considering the fundamental significance of the construction sector in employment creation, capital formation and its aggregate spillover effects, it is clearly an important sector in the economy. That does not mean that it drives economic growth. This makes it all the more important to identify the minimum necessary and sufficient conditions for economic growth. As economies develop from LDC status through NIC status to AIC status, construction sector spillovers accrue to propel productivity in other sectors of the economy, most notably, the services sector. Further research needs to establish a reasoned explanation of the relationship of the construction sector to economic growth, with emphasis on post-industrial developmental consequences. Insight into these issues will enable LDCs to better manipulate their economic policies to grow their economies and provide progressive policy alternatives for AICs to achieve economic recovery and progress towards post-industrial country (PIC) status or super-AIC status.

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The paper chase; learning design and construction management in study groups

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Abstract

The expectations placed on educators are increasing to the point where many academics are beginning to feel that they are unrealistic. We face the expectation that we can deliver more knowledge, quicker, with fewer resources, and fewer teaching hours, and make it easier and more fun for students at the same time. This is was our mandate when we were asked to develop a new first year master's course in design and construction management at the faculty of architecture of TU Delft. We chose the working title "everything you ever wanted to know about design and construction management in seven weeks".

Inspired by the film The Paper Chase, in which American law students collaborate to cover an enormous amount of literature in a relatively short time, we decided to adopt a teaching method based on the use of study groups, or more precisely formal learning groups. In short, we assigned the much more literature than a single student could cover in the allotted time, and assigned the students to work in groups, teaching each other the essentials from their share of the assigned readings.

The course is divided into seven themed weeks – roughly following the design and construction process. Each week has a specific reading list, and is concluded with a workshop assignment that serves to illustrate how the knowledge drawn from the readings can be applied in practice. The week begins with an introductory lecture to inspire the students and help them orient themselves. Working in groups of 7, the students are each assigned a portion of the total literature for that week. On Friday morning the students meet to discuss the readings, and are then assigned their workshop task. At the end of the afternoon, the results of the workshop are presented and discussed with the students. At the end of the period the students sit a closed book examination.

We have now run the course twice. After the first run, the course was evaluated through the University's quality assurance process, and by the departmental student association. While the feedback has clearly indicated areas for improvement, the students were enthusiastic about the study group concept and the way working as a group allows them to cover a large amount of literature. This feedback was used in substantial improvements for the second runoff the course. Informal feedback from the second run continues to support the use of study groups.

Keywords: Design and construction management; Study groups; Formal learning groups, Course design; Learning methods

1. Introduction & Background

In 2010 the authors were confronted with a seemingly impossible task: to develop a 7 week half time course that would deliver the content previously delivered in courses totaling 16 weeks full time. This paper is about how we attempted to accomplish this.

1.1 Background

The department of Real Estate and Housing was established 1992 within the faculty of architecture of Delft University of Technology, in response to the demand from practice for a broader range graduates. A Dutch government report made clear that although more than 80% of the students of the faculty graduated with a design profile less than 50% got an employment as architectural or urban designer (*Verkenningscommissie Bouwkunde, eindrapport*, 1988). The report advised the faculty to broaden its' scope suggesting profiles including process and project managers.

The curriculum for this new department, Project and Real Estate Management (Bouwmanagement & Vastgoed Beheer), was based on the faculty model of two years of shared basic courses, followed by three years in the departmental track, with each year divided into five periods or modules. The Project and Real Estate Management program was consisted of 4 core modules, two modules of electives, and 4 combination modules, one for each of the other departments in the faculty: Architecture, Urbanism, Building Technology and Social Housing. The core modules had an emphasis on the acquisition of knowledge, the combination modules an emphasis on insight and skills. The program culminated in a year-long thesis project.

From 1999 the Department had to adapt to the new Bachelor□Master structure (BaMa) in conformance to the Bologna Declaration (*Joint declaration of the European Ministers of Education convened in Bologna on the 19th of June 1999*, 1999) calling for the harmonization of educational systems. At the same time the Department of Social Housing merged with the Department of Project and Real Estate Management to form the Department of Real Estate and Housing (REH). The change to the BSc□MSc system also entailed change to a three year BSc program for the entire Faculty of Architecture, followed by a two year MSc degree program in each of the faculty's departments. At the same time, the Faculty switched to a 2-semester system. The result was that what had previously been a three-year program in project and real estate management became a two-year program in project management, real estate and social housing. With the retention of the final thesis year, the course component of the program was reduced by half, while having to incorporate an additional discipline. Streaming in the second semester mitigated this somewhat.

The most recent reform was the decision to eliminate streaming, and to implement a fully integrated REH curriculum. The resulting curriculum consisted of one semester of courses devoted to knowledge acquisition in the three disciplines, project management (now renamed design & construction management), real estate management, and housing policy, and two additional subjects – management fundamentals and research methods. This was followed by a semester of department broad skill building courses covering the application of the knowledge acquired in the previous term, and then the year-long thesis. With this final reform, the time allotted to the acquisition of the basic knowledge of design & construction management had now been reduced from nearly half a year full-time to 7 weeks of about 40% of the students' time.

1.2 Real Estate and Housing Curriculum

In depth knowledge of the core domains of RE&H is the essence of the first year of the new curriculum. This is caused by the mission of the department to integrate the various core subjects and to provide students with a broad knowledge of the whole domain of RE&H.

In the first semester emphasis is placed knowledge acquisition, more specifically on general management knowledge (for instance from project to portfolio and program management, general management, governance, policy, leadership, teambuilding and team behaviour) that is valid for all focus areas of RE&H.

In the second semester the program focuses on skills acquisition. Students gain skills by experiencing practice roles and by describing, analysing, researching and improving practice based professional behaviour, based on design, gaming and case studies covering the whole range of the department.

In the third semester the students start with their individual MSc graduation project accomplished with an in departmental program on research methodology and their free electives program, which might be used to deepen their knowledge on the graduation subject chosen. The fourth semester is in total dedicated to the individual MSc thesis project. In this phase synergy between the work of staff and students is key, while most students do their thesis work connected to practical issues with public and private organizations.

By providing a program that explicitly starts and ends with professional profiles, with a strong focus on integration, fundamentals and academic quality, the department is determined to offer a distinguished program for all those with a bachelor in architecture, building, construction, environmental and real estate sciences a polytechnic or academic background, who would like to complement their basic knowledge of the domain with an extensive broad managerial MSc course, aiming at the top of applied knowledge on excellent leadership to add value to the built environment.

Within the new curriculum only 7 ects was left to provide the students with the basic knowledge of design and construction management. This course would run parallel to a course in Management Fundamentals in which in a general introduction to management and project management is provided.

1.3 Everything you want to know about design and construction management

In designing the course we chose to be guided by the working title "everything you ever wanted to know about design and construction management in seven weeks". The exact time available to us was 7 ECTS or 196 study hours. A further limitation was the faculty standard for the maximum hours of student staff contact – 33% or 63 hours in the case of this course. Finally, institutional regulations regarding maximum permissible proscribed student work-load limits instructors to assign no more than 5 pages an hour of material upon which students may be examined. Assuming we use our maximum on contact hours, group work and workshop time the amount of pages is thus limited to a maximum of 665 pages.

The aim of the course was to provide students with a thorough understanding of project management based mainly on PMI standards, and additionally with insight into how this knowledge applies to the practice of construction projects in general and design projects in particular. We also wanted to confront the students with recent, or controversial research papers in order to provide the students with insights into the on going areas of investigation and controversy in project management research, with the intention that students develop an ability to think critically about project management literature. Our goal was to maintain high academic standards while achieving an increased efficiency in delivering the knowledge components of the Master's degree program.

2. Advantages of cooperative learning

Inspired by the distant memory of the film The Paper Chase (Bridges, 1973), in which students formed study groups in order to deal with the extremely demanding 'Socratic' methods of a charismatic law professor, we decided to implement a similar strategy. Obviously Hollywood provides neither convincing evidence for the effectiveness of study groups, nor guidance in how to implement them. For these we turned to more authoritative sources.

The basic concept of the study group, or more broadly of cooperative learning arises in part from the work of Kurt Lewin and John Dewey (Schmuck, 1985), and their independent interest in the importance of learning to cooperate in modern societies. In their view the validity of a teaching activity or a group exercise arises from the belief that learning to cooperate in school would facilitate cooperative activity in society as a whole. Through cooperative learning in which students are trained to be good group members, are graded as a group, and are continuously evaluating themselves in their function as group members the education experience is shifted from traditional competitive learning situations (win-lose) to collaborative learning situations where students success is mutual (win-win).

As our students are already familiar with group based problem solving, based on their design studio experiences in the shared bachelors curriculum, our interests in group learning was in the benefits it can offer in improved learning course content, and acquiring knowledge. A review of the literature on active learning concludes that collaborative learning, here defined as "any instructional method in which students work together in small groups toward a common goal […] 'works' for promoting a broad range of student learning outcomes. In particular, collaboration enhances academic achievement, student attitudes, and student retention. The magnitude, consistency and relevance of these results strongly suggest that engineering faculty promote student collaboration in their courses." (Prince, 2004, p. 223 & 227). The same study goes on to conclude that cooperative learning, defined as "a structured form of group work where students pursue common goals while being assessed individually […] that cooperation is more effective than competition for promoting a range of positive learning outcomes. These results include enhanced academic achievement and a number of attitudinal outcomes." (Prince, 2004, p. 223 & 227) Another author remarks that "… regardless of the subject matter, students working in small groups tend to learn more and demonstrate better retention than students taught in other instructional formats." (Davis, 2009, p. 190)

In addition to these benefits we were attracted by the belief that group based learning helps to motivate students. When learning in groups students are mutually reliant and each member feels responsible to and dependent on the others. No one can succeed unless all in the group succeed (Davis, 2009).

Two forms of learning groups were of interest to us: formal learning groups and study groups. Formal learning groups undertake specific assigned task(s). Students work together until the task(s) is finished, and their work is evaluated. Groups may function for from several weeks to the entire term. Study groups are primarily used to encourage students to provide support encouragement and assistance to each other. Study groups operate informally outside scheduled contact hours, and typically run for an entire semester. (Davis, 2009, p. 191) One can see these two groups as providing formal and informal opportunities for cooperative learning respectively.

In choosing to employ study groups, or formal learning groups, three factors were decisive. The first was the need to cover a large body of material and to do so in a way that could encourage a critical engagement with the material. The second was to stimulate the students to begin their work early, and to maintain a good work rate throughout the course. The third was to encourage a more effective and engaged learning process through requiring students not merely to read a series of texts and write an examination, but to summarize and share the knowledge they drew from their readings with other students. The intention was to draw students into an engagement with the material through obliging them to discuss their readings with their colleagues.

We believed that group leaning with it's promise of greater effectiveness and motivation would be especially helpful in our mission to deliver, and help students learn, a large quantity of knowledge in a brief period.

3. Action research

The development of the new course was undertaken according to the principles of Action Research. Action Research was an approach to conducting research developed by Kurt Lewin and his associates in areas where there was little certain knowledge, little opportunity for controlled experiment, and a need to understand the implications and outcomes of applying ideas in practice. Lewin and his followers developed a program of intervention based research focused on group dynamics and cooperation (Deutsch, 1949; Lippitt, 1947). This approach "combined generation of theory with changing the social system through the researcher acting on or in the social system." (Susman & Evered, 1978) The authors had experience with action research from a previous project in the application of blended learning in a project management course for first year BSc students (Prins & Heintz, 2009). Key to our approach was the notion of structured reflection in action (Schön, 1983).

The development of the course was therefore seen as cyclic process in which one moves through the stages of diagnosis, action planning, intervention, evaluation, reflection, and finally diagnosis for the new cycle (Davison, Martinsons, & Kock, 2004). The course designers reflected upon the changes in student behaviour, student work, evaluations by students, and upon the instructor's own experience to develop generalizable insights in the use of cooperative learning, and to evaluate the success of the new course design with an emphasis on what further improvements could be made. In planning for the new course we developed the following action research questions:

1. To what extent will students accept cooperative learning in the form of formal learning and study groups as a desirable means to learn about design and construction management?

2. To what extent can cooperative learning in the form of formal learning and study groups motivate students to learn a large body of knowledge in a short time?

3. How effective can cooperative learning in the form of formal learning and study groups be in helping students to learn a large body of knowledge in a short time period?

4. To what extent can the insights developed from the answers to the above questions be used in educational practice?

Criteria for evaluation of the success of the intervention (the use of formal learning and study groups) included:

1. Level of student participation

2. Quality of student reports

3. Quality of discussion and debate in group meetings

4. Performance of students in exams

5. Student satisfaction as expressed in questionnaires and reflections.

Evaluation was performed with the assistance of the University's quality assurance team, the departmental student association, and informal feedback provided directly by students. Reflection took the form of discussions among the course designers and other instructors over their experiences and observations in teaching the course, evaluating student work and examinations, and in conversations with students.

4. Course Design

In designing the course we began with the intuition that students would be confronted with a large body of knowledge that could only be learnt though the application of cooperative learning in the form of formal learning groups. Our first step, therefore, was to define the body of knowledge to be learned through selecting the principle readings. We choose three books: ***The Gower Handbook of Project Management*** (Turner & Simister, 2000) consisting over 800 pages to cover general project management, ***Managing Construction Projects*** (Winch, 2002) consisting over 500 pages to cover the application of project management to construction projects, and ***Getting There by Design*** (Allinson, 1997) consisting of over 200 pages to cover project management issues in design projects. In addition to this a number of research papers and other shorter readings were assigned, bringing the total number of pages to be digested to approximately 2000. We purposefully allowed for overlap and differences between sources in order to encourage students to make comparisons between different points of view, and to confront the constructed nature of project management knowledge.

With this as a departing point we next started to search for didactical methods to provide students with the rich amount of content we'd like to offer them, while enhancing student motivation to undertake an admittedly challenging course, complying with the Faculty's regulations regarding acceptable workloads.

Our idea was rather simple: if we divide our students into study groups, in which each of the members is responsible for a distinct part of the readings, which has to be summarized, analyzed and commented on, at such a level the other group members can acquire the required knowledge based on the condensed results of the other group members, we were able to let them study much more pages as the usual norm.

Within Black Board, the faculties learning system, each of the groups is asked to build a so called 'Wiki' (like Wikipedia) of the materials to be studied. At the end the wiki's have to be combined into one course wiki, on which the examination is made. Groups might make suggestions to the teachers on examination questions. A fundamental aspect of this course is the use of a wiki to summarize the readings and to provide students with a single text to study in preparation for the exam. Participation in the creation of the wiki is essential to the course and will be monitored. Participation includes not only uploading summaries of assigned texts, but correction of the summaries already posted, addition of comments and links indicating connections between the various readings, links to external material that is directly relevant to the readings, and reflections on the content of the readings.

The study groups will function to amplify the students' ability to read and study the large range of literature relevant to the aims of the course. Each week, the students will be assigned a series of texts. Each student must take a share of the texts and prepare notes or a summary. The students then share notes and discuss the texts with each other in the study group. Planned (and required) study group meetings are scheduled for Thursday afternoon each week. The students will then participate in the construction of a wiki in which students will consolidate their notes on each of the assigned texts. In this way, we can assign a broader range of readings than would otherwise be possible.

Each student would be assigned to two groups.

1. The first, 'real', 'study group' functions both as formal learning group and as project team. During each week students would study their assigned readings, share them with their group members, and apply the knowledge gained in a thematically related workshop task derived from a real case derived from the actual practice. Each week a leader would be assigned who would have the responsibility to ensure that all the assigned material is covered during the study group

meetings. The 'leader' will also ensure that the other students know what work has to be done during the week and that students understand their role in the workshop. In the unscheduled weeks before the examination it was expected that this group would continue to function as a study group.

2. The second, 'virtual', group is the wiki-group. Students in a wiki group would be assigned the same literature during the course and would be collectively responsible for providing summaries of this literature in the wiki. Wiki groups would also prepare and submit exam questions on the reading material, some of which may be used in the final exam.

The study groups and wiki groups would be active throughout the course. First, during the contact weeks, the study groups will focus on knowledge acquisition. Then during the self-study week, the study groups will focus on review and consolidation of the knowledge acquired in the contact weeks.

Each of the seven course weeks would be structured around a theme running roughly sequentially through a project. The selections from the main texts and additional readings were assigned by, and each week taught by different instructors based on their expertise. Each week (in practice the last 2 and ½ days of each week) would be structured around an introductory lecture, 1½ days for reading, a meeting of the study group for knowledge exchange, and the performance of a case based task in a workshop setting. The week was to conclude with the submission of a task report and a discussion. The seven weeks of course work were then to be followed by two unscheduled study weeks and an examination. The wiki was intended to serve as the 'real' textbook for the course – that is, officially the students would be examined on the wiki. In designing the examination, instructors were required to pose questions based on the literature, to which they could find the answers in the wiki constructed by the students.

5. The course in practice

5.1 The first round

The first round of the course was conducted in as described above. The Students were invited to evaluate the course through a focus group evaluation organized by the departmental students' association, and by a questionnaire organized by the university's quality assurance group. The questionnaire took the form of a rating of a list of aspects of the course on a 5 point scale.

5.1.1 First round evaluation

In the focus group students were generally quite positive about the course and course design. Students in particular valued the study group approach. They found that studying with their peers reinforced good study habits, brought them into a more engaged relationship with the study texts. Students were more critical about the wiki, finding that the purpose of the wiki was not clear. They wanted more guidance in what was expected of them in preparing the wiki. Specifically, as the wiki itself was not graded, students felt that they did not share an adequate incentive to produce quality work in the wiki. The questionnaire results echoed the focus group. The study group was the most highly valued aspect of the course, whereas the wiki was scored a bit lower. In the context of the overall evaluation of the Department's new curriculum, and benchmarked against the scores of other MSc courses within the Faculty, the students score for our new course was relatively high.

5.1.2 First round reflection

The course staff was quite positive about the course design. The staff clearly appreciated seeing students working in groups in the assigned studio space, whereas normally our students work away from the faculty. In class and in study groups, the students were enthusiastic, and hard working. And performance on the contextualizing tasks was fairly good. From student comments during the course and in the evaluations it was clear that they attributed more importance to the contextualizing task than was intended, and where the task did not incorporate the entire range of the literature for the week, students understood the remaining literature to be extraneous. Both staff and students were unsatisfied with the examination – a multiple-choice examination with only fact based questions. The exam was not challenging enough for the students, and did not serve to differentiate between them.

The instructors observed that there was a very high degree of participation with almost no absenteeism. To the instructors' eyes the students working in groups were enthusiastic and focused.

The quality of student reports from the weekly tasks was good, in that the students demonstrated the ability to apply the knowledge acquired during the week to the assigned task. However, the reports did not display the desired level of reflection on the difference between reading about design and construction management and performing a task in this context. The discussions similarly lacked the desired reflection.

All students passed both the semester work and the examination. However, the instructors judged that the examination in particular had not served to adequately distinguish between the relative performance of different students.

5.1.3 First round diagnosis

What was clear, however, was that the students did not always understand in depth how the course was supposed to work. They consistently focused their energies on the completion of the weekly task rather than on knowledge acquisition. They attended to the readings strategically selecting those passages that applied directly to the assigned task. Further their contributions to the wiki were designed primarily to generate good metadata – i.e. to have visibly contributed many words to the wiki, rather than to distill and re-present their readings to their colleagues. The wiki was not made to study from and was not found to be an effective study aid.

5.2 Second round

5.2.1 Second round planning

The most important improvement for the second round was to improve the description of how the course was structured and intended to work. Students were instructed in the intended functions of the formal learning groups and the wiki groups. For the second cycle the weekly themes were revised.. The readings and the tasks for each week were chosen to better reflect the weekly theme, and to ensure a more even workload from week to week. Students were given more extensive instruction on the wiki. The importance of revising wiki entries was emphasized, as was the point that quality of input rather than volume would be valued. (We still do not plan to directly evaluate the wiki.) Finally, the decision was taken to more carefully structure the end of each week, with the deliverables to be submitted in time for a quick review by the instructors before a concluding discussion on both the task and the knowledge covered during the week.

5.2.2 Second round evaluation

Questionnaire results showed a marginal improvement over the previous round. In open questions students particularly valued the connection between theory and practice, and the way the course worked to capture the students' interest. The focus groups were more specific. Students indicated that they did discuss the literature in their study groups, and valued the fact that by dividing the readings among the students each student was assured a chance to contribute. On the other hand, students did not discuss the readings in their wiki groups, preferring to divide the work amongst the group members, Comparison of success rates for students between the two cycles is difficult as the exam was redesigned to include both insight oriented multiple choice questions and open questions. Due to this, and perhaps due to the precedent set by the unfortunately too easy first exam, the students performed significantly more poorly on the exam in the 2nd cycle. However, the staff received surprisingly few complaints about this.

5.2.3 Second round reflection

While students and instructors remain very positive about the use of formal learning groups, it is clear that the desired effectiveness has not yet been fully reached. Students in particular continue to express the belief to their instructors that the formal learning groups were very beneficial. Instructors observed again in the second cycle the high rates of participation among the students. In particular the quality of the discussions at the conclusion of each week was much improved over the previous round. However, the balance improved between the two rounds, students continued to place too much emphasis on the task as opposed to the acquisition of knowledge. Most importantly, the students have not uniformly embraced either the notion of critically comparing the different sources nor the use of the wiki as an effective study aid. While some groups did engage in critical comparisons, and did create summaries of the readings for use in the wiki, they reported that they relied more heavily on their own summaries rather in the class wide wiki in preparation for the examination.

One factor in student performance seems to have been the grading scheme. Many students seemed to follow a carefully calculated strategy – focussing only on the work that was directly evaluated. With approximately half the final grade generated by the group work, the focus on the task should perhaps not be very surprising. The fact that staff did not grade the wiki itself created a large distinction between the earning of grade points for the task, and the earning of grade points in the examination. The course designers and instructors concluded that only grading the wiki itself would make the connection between the learning to take place during the instruction weeks, and the learning in preparation for the examination. A second consideration was the generally high performance of students on the examination during the first round. Students may have well believed that the examination did not require a great degree of effort to prepare for – especially after having achieved relatively high grades for the work during the course. If this is true than the changes made to the examination – to make it function more effectively to test the course material and to distinguish student performance – may have caught the students by surprise. The students were informed of these changes, but whether they anticipated the difference in degree of difficulty is hard to assess.

Looking forward to future rounds, the course designers while being confident of the success of the formal learning groups will need to re-evaluate the use of the wiki. In one sense, that of fitting the ambitious course goals within the constraints of curriculum and workload regulations, the wiki is crucial. On the other hand, it has yet to be successfully implemented as a study tool.

6. Conclusions

In terms of the criteria for evaluation of the course we can conclude partial success. Student participation and work rates were high during the instruction weeks for both rounds. The quality of task reports was also high in both rounds. The quality of concluding discussions was much improved from round one to round two. It is not possible to make any conclusion about student performance on the examinations as the difficulty of the examination changed dramatically from the first to the second round. Finally, students expressed a high degree of satisfaction with the formal learning groups and with the course in general, while remaining critical about the wiki.

In terms of the action research questions, the following conclusions may be drawn.

1. Students will accept cooperative learning in the form of formal learning and study groups as a desirable means to learn about design and construction management.

The students in the two rounds of this course readily accepted the use of formal learning groups, and these groups were reported to continue past as study groups in preparing for the examination.

2. To what extent can cooperative learning in the form of formal learning and study groups motivate students to learn a large body of knowledge in a short time?

Students displayed high degrees of motivation in their group work – devoting considerable effort to acquire the knowledge from the readings they deemed necessary to complete the workshop task.

However, the attention of the students needs to be drawn to the goal of more general knowledge acquisition.

3. No conclusion may yet be made about the effectiveness of using cooperative learning in the form of formal learning and study groups in helping students to learn a large body of knowledge in a short time period.

No direct comparison could be made to earlier learning patterns, while the difference in difficulty between the two examinations did not permit any conclusions to be made over the duration of this research.

4. Insights developed from the experience of developing and running this course are applicable in educational practice.

Here the question is which insights. It is hardly surprising that researchers conclude that they can endorse the use of formal learning groups. Such groups are already in use in many settings. The most valuable insight generated here is that the design of the course around the formal learning group may be the most important factor. Students easily grasped what was needed to perform well in their groups. More crucial to the success of the course was structuring the tasks to be performed and the grading incentives to direct the student efforts towards the desired ends. Although the instructors have identified a number of areas for improvement in both the design of the tasks and the grading incentives, we were satisfied that we had achieved substantial success in our ambitions to deliver to students a substantial body of knowledge of design and construction management in a very brief period of time. Collectively, the students in each formal learning group read over 2000 pages of literature, including not only textbooks, but also current research papers. Although there is clearly still room for improvement in the use of the wiki, given the student feedback, we are confident that we have been successful in developing a means of engaging the students with a large body of didactic and scientific literature, including original source materials, recent doctoral dissertations, journal and conference papers. Students were confronted with a range of different departure points and paradigms, stimulating them to understand differences in scientific and practical approaches. Despite the heavy work-load, students remained enthusiastic about the subject, and keen to learn more in the following semesters. We therefore believe we may claim that we have indeed found a way to deliver quite a lot of “everything you ever wanted to know about design and construction management in seven weeks.”

7. Acknowledgements

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Constructing better places: Integrating disciplines in built environment education.

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Abstract

The paper notes the growing international emphasis upon place making as a component of regeneration initiatives and illustrates the difficulty of achieving high quality integrated results in practice. This sets the context for discussion of the challenges facing interdisciplinary working in the built environment. The critical role of synthesis in producing quality places in urban redevelopment, regeneration and conservation is taken as a starting point for a brief examination of the obstacles to achieving it in practice. These include the diverse interests at work at different spatial and temporal scales and the quite different instruments and approaches that are used in planning, design, construction and property management. These complexities set the context for discussion of potential opportunities for interdisciplinary problem based action learning in initial professional education, lifelong learning and practice. It is concluded that, while there are many inherent challenges more effective processes of contextual appraisal could provide the basis for more holistic and integrated interdisciplinary learning and practice, and the making of better places. Practical steps through which this theoretical argument could be pursued through interdisciplinary field study visits and scenario based role play are finally considered as an opportunity for research.

Keywords: Place-making, Interdisciplinary, Integration, Action Research.

1. Introduction

This paper draws upon previous research into interdisciplinary pedagogy in built environment disciplines (Chapman, 2009) and urban design and place-making (Chapman, 2011) and proposes new action research in pursuit of greater integration in education and practice. Well-designed and people-friendly places have been increasingly prioritised in public policy (see for example Jacobs, 1961, Lynch 1981, Tibbalds, 1992, Landry, 2006). Local communities and businesses have also become vocal about the qualities of the places around them. While examples of distinctive and enjoyable historic and contemporary places can be found internationally but the exemplars are the exception and in many places the qualities appear to be progressively diminishing. This is not caused by the absence of shared perceptions of what qualities are desirable, but more from the difficulty of actually producing them in practice (Relph, 1987, Whitehand, 1991, Chapman, 2011). The problem is international and exemplified by the starkly contrasting qualities between two recently created pedestrian routes in Birmingham, UK. One is a distinguished new pedestrian route reconnecting central Birmingham with its parish church (see Figure 1) and the other is an obstacle course along the primary pedestrian route between two major stations (see Figure 2). They intersect with each other and the contrast in quality of place is stark. As observed by Rook (2004, p. 8) *"One suspects that it is easier to make good places special than [it is to] make the ordinary places of the city better, yet it is raising the quality of the ordinary places that we should be concerned with"*.

Figure 1:A distinguished new place and pedestrian route in Birmingham. UK.

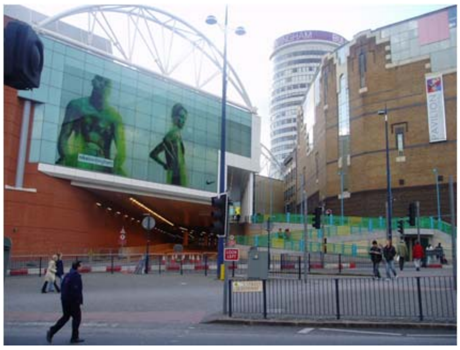

Figure 2: A key part of a primary pedestrian route between two stations in central Birmingham.

Built environment disciplines span a wide diversity of concerns and actions, from the immediate realisation and management of development and places through to the longer term spatial planning at great territorial scales. Each is concerned with the development and management of our living environments, where, as Cortese (2003, p.16) observes, *"Interactions between population, human activities, and the environment...for a secure, just, and environmentally sustainable future are among the most complex and interdependent issues with which society must deal"*. Thus the responsibilities are great and the need to secure real synergy and added-value from the combined results of our actions is imperative. But are we up to the challenges? While each of the disciplines is inextricably linked they may be working at quite different spatial and temporal scales; using different approaches and instruments for action; and being guided in many ways by quite different value systems. Are these different disciplinary horizons and goals sufficiently or explicitly appreciated? Do they divide us as much as our institutional, disciplinary and professional structures do? How can education and training programmes be devised that help to bridge the complex borders?

As early as 1969 Constantinos Doxiadis recognised these complexities and captured them in Figure 5. Verney quotes Doxiadis saying "…the questions to be asked about the city will…run into billions and trillions. Have you decided which of these it is that you want to ask?" (Verney,1969, p. 50). It is this very complexity that is at the heart of the challenge for oversimplification inevitably results in over-simplistic and ineffective responses.

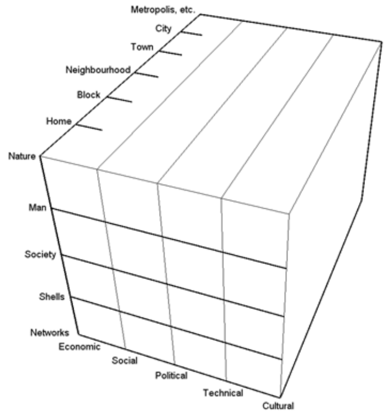

Figure 5: The diagram used by Doxiadis (Source: Verney, 1969, p. 51; redrawn by Joe Chapman, 2007)

In practice the problems that arise from inadequate integration (or synthesis) between actions are experienced in poor outcomes. Poor quality places are often left at the interfaces between otherwise excellent developments, and the existing urban fabric. Immense trauma can be caused to the quality of places during large scale or long term development programmes. Unsatisfactory compromises can also arise late in implementation when significant weaknesses in earlier decision-making necessitate late changes. Put simply, the 'problem' is how could we collectively secure higher quality and integrated outcomes from the multitude of disconnected actions that occur in complex built environments?

2. Breaking the silos: Recurrent attempts at integration.

Efforts to promote integration between built environment disciplines have been made and in the UK Latham (1994) and Egan (1998) explored the opportunities for integration in the construction industry. Egan later (2004, p.13) later took a wider perspective suggesting '…*that attempting to upskill professionals in isolation will not produce the outcomes we are seeking. Instead success will lie in changing the behaviour, attitudes and knowledge of everyone involved"*. Collier et al. (1991, pp. 5-7) had earlier promoted the idea of 'a common language (and) culture…' for all built environment students proposing 'commonality' and 'common modules' of study. This approach was also promoted by the Construction Industry Board (1996) but it is fair to say that the process was fraught with interpersonal and operational difficulties, and a fear that this approach actually resulted in the lowest common denominator. Wood (1999, p. 373) also found that common programmes were problematic and recommended that '…*more needed to be done to define the terminology and differences involved in interdisciplinary and inter-professional studies" as well as* greater emphasis upon interdisciplinary project working.

In engineering Gann and Salter (1999) concluded that the levels of uncertainty and risk meant that challenges in practice do not present themselves in neat disciplinary forms and that interdisciplinary engagement is critical to problem solving. Their conclusion was that "…interdisciplinary thinking requires an appreciation of different methods and approaches to problem definition and solving" and they proposed *"...integration of different perspectives into a unified whole" by selecting "...concepts, methods and techniques that transcend rather than reproduce the boundaries set by formal (academic) disciplines"* (Gann and Salter, 1999, p. 18). Chapman (2002) also concluded that professional, disciplinary and administrative 'boundaries' all present practical, if unintentional, obstacles, gaps or divides that are difficult to overcome. Seymour (2006) identified underlying tensions because although the language and aims espoused by differing disciplinary and interest groups, or local gangs as Garfinkel and Wieder (1992) called them are often the same, the meanings they give to them frequently differ. Exploring "the complexity of decision making from a multistakeholder or process viewpoint" Mayer and Seijdel (2005, p. 403) drew upon the examination of "…institutional barriers to sustainable construction" undertaken by Van Bueren and Priemus (2002) and conclude that "experts from various disciplines must be able to communicate and share knowledge effectively" (Mayer and Seijdel, 2005, pp. 403-5). This conventional wisdom; that better communication, understanding and collaborative working amongst diverse 'actors' and between the professional 'silos' will help to improve integration of policy and action (Rogers, 1999; Egan, 2004) encouraged various initiatives but in practice and in education many of the core problems still exist.

The processes of visioning, planning, designing, developing and managing are complex and reiterative and have three dimensions; implementation, decision-making and analysis .
These are shown here in what might be considered a 'reverse order' because our daily experience is of the outcomes of the processes. These are driven by the decision-making that has led to them, involving a multitude of individual and organisational choices, some of macro-scale but mostly a myriad of micro-decisions being taken daily. This multiple decision-making process is in turn dependent on the quality of the information that is available. If that information is fractured or partial then how can there be any effective integration through the design or implementation stages? While the central concern here is the quality of outcomes at the point of implementation the place where improvement could be made is within the complex dynamics of earlier stages. While better communication could be seen as a possible means of integration in practice the logistical difficulties are immense. Could an actively produced and widely shared place centred knowledge base provide the foundation for more integrated actions and outcomes?

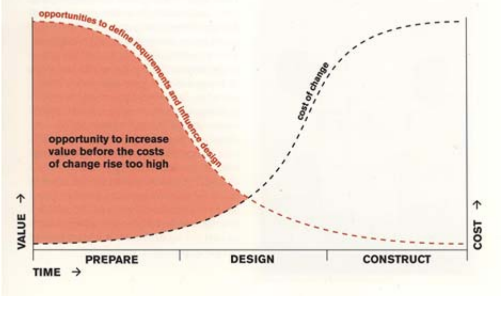

Figure 4: The opportunity increase value.
(Source: CABE, 2003 p. 22; reproduced by permission).

The three dimensions; implementation; decision-making; and data and analysis; relate well to the three stages of development illustrated by CABE (2003) as shown in Figure 4. The critical place of the preparation stage in reducing costs, increasing value and improving quality in design and development is clear.

Yet it is this key preparation stage that is inherently weak when we look across the multiple and frequently disconnected projects and actions occurring daily. Box 1 develops the framework further to capture the critical role that management and stewardship plays in securing sustainable quality and integration, and the underlying ingredients of the processes involved.

Preparation Data and analysis (Understanding) Preparation, inception, planning **Strategy**	**Design** Decision-making (Policy) Design and specification **Prescription**	**Construction** Implementation (Management) Construction and use **Production and Husbandry**

Box 1 Key stages in practice

3. Spacio-temporal disciplinary scales

Scales of interest and actions are significant because the aims that each discipline pursues are often subtly different (Moudon, 2002, Chapman, 2009). Each view is correct but partial" (Lynch, 1962, p. 9). It is important to appreciate how they differ and to consider where greater synergy could be developed. Key aspects include the objectives of analysis for each discipline, the different spatial scales and levels of resolution that they work at, and the timescales with which they are concerned. The issues were examined by Moudon (2002) who identified the scale, grain and areal extent used as follows;:

- Architects being primarily concerned with the plot, or the site of their commission.
- Urban designers concerned with "groups of plots up to entire cities".
- Land-use planners concerned with "activity zones … excluding buildings or plot s
- Regional planners who use a level of resolution at yet a higher level of abstraction" (Moudon, 2002, p. 38).

To this nascent typology we must add;

- Building surveyors concerned with strategic life-cycle management.
- Construction project managers concerned with effective production.
- Real estate managers concerned with property portfolio management (adapted from Chapman, 2009, p.7).

Although Moudon (2002, p. 38) claims "only architects and urban designers consider elements of urban form" with "all other allied professions replacing these elements by abstract concepts such as density and land-use mix" this is clearly not true of the surveying, engineering and construction management professions where the concerns are very tangible and have immediate consequences for urban form and quality.

4. Instruments of action

The ways disciplines translate aspirations into strategies, plans, designs and action are diverse although the ways in which they communicate and the instruments used can be seen as a relatively simple typology, as outlined in Box 1.

Policy and principles - Issues based	Implementation - Place based
• Transnational spatial strategies • National spatial strategies • Regional spatial strategies • Sub regional spatial strategies • Local plans and development frameworks • Statements of corporate responsibility **Policy and principles - Place based** • Countryside characterisation studies • Urban characterisation studies • Village design statements • Area management plans	• Area action plans • Development briefs • Master plans • Design and access statements • Legal covenants **Implementation - Development based** • Detailed development design • Development evaluation • Inception and feasibility studies • Property management plans • Specifications of works • Development contracts

Box 2 An outline typology of Built Environment instruments

The most clearly defined of these instruments are building plans, specifications and statutory development plans, but there are a range of less well defined and indeed optional instruments are used, albeit patchily. The relationships between the scales and types instruments used was explored by Chapman and Larkham (1999) who concluded that, far from there being a smooth coordinating continuum or hierarchy, there are significant gaps and discontinuities, as well as confused responsibilities between them. Figure 5 illustrates the broad pattern of relationships

Appraisal is invariably prepared project by project and guided by the disciplinary theories, practices and knowledge base of each project team. Different ‘scales’ of analysis are used to pursue quite different approaches, ranging from the broad coordinating framework through to precise specification and prescription. The aim of analysis varies greatly and each requires a different mindset and style. The levels of depth or generalization required span that needed to describe and understand how places have developed ab initio; the ‘abstraction’ that may be needed to support policy formulation in planning; and the prescription that is involved in urban design and architecture. For example, a comprehensive Design and Access Statement may be prepared for a substantial development; an Urban Design Framework for the locality; and Supplementary Planning Document guidance about a generic topic, and a number of individual sites may have careful examination, but the analysis and appraisal that underpins each is likely to have been undertaken quite independently, and differently.

If we consider places holistically this division may prove counter-productive as in terms of place making the parts are inextricably part of the whole. Each discipline uses data and analysis that are limited to the immediate task, project or action, and thus it is incomplete and inadequate for integration between actions. As Punter and Carmona (1997) observed *"…most appraisal processes have been very partial, both in the geographical sense of tackling only parts of the district or borough, and in the systematic sense of covering only selected aspects of design and environmental quality"*.

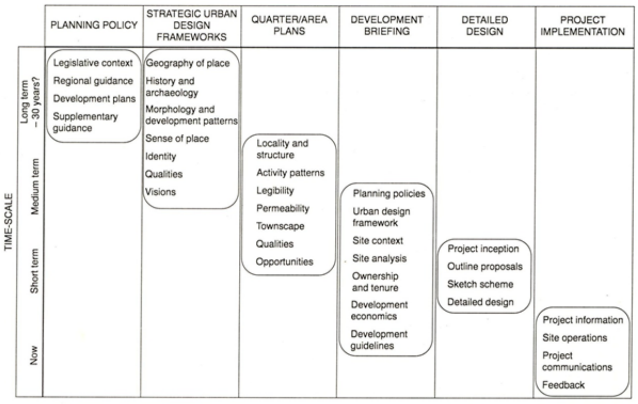

Figure 5: Timescale, policy and action: linking planning, urban design and architecture (Source: Chapman and Larkham, 1999)

The UK Commission for Architecture and the Built Environment (CABE, undated c. 2008) related 'planning design tools' to spatial scale and showed the potential of Area Action Plans as an instrument for active management (see Figure 7). The New Zealand Urban Design Protocol (New Zealand Ministry of the Environment, 2007) also inter-related scales of action, type of instrument and scope and coverage (See Figure 8) but the apparent elegance of the hierarchy of instruments illustrated in theory has not yet been achieved in practice. Both are concerned with translating broader spatial policies into more tangible form on the ground.

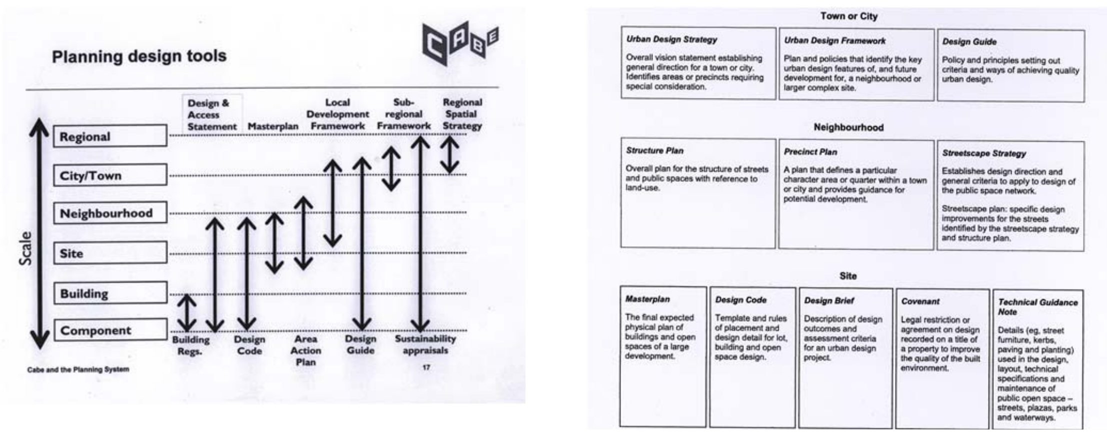

Figure 8: Linking planning tools to design and spatial scale (Source: CABE presentation, reproduced by permission)

Moudon (1992, p. 334) differentiated between the knowledge required in 'understanding' places and the prescriptive skills involved in 'designing', making a clear distinction between exploring "what was/is", and proposing "what should be". This is significant for built environment education and it may provide a basis for conceptualising approaches for our pedagogy and andragogy. It challenges us to explore in depth what appraisal skills built environment students should be enabled to develop to underpin their decision-making and prescriptive skills. Devising approaches that enable our students to engage with this wider context and to make connections between their own disciplinary interest and others is a key task, and success in this could provide a basis for greater synergy between disciplines in practice. In order to do this learning activities should encourages students and tutors to share perspectives in ways that enables them to develop together to achieve outputs undifferentiated by discipline (Cooper, 1997).

Increased integration cannot be achieved at the implementation stage when the strategic and critical tactical decisions have been taken. Some integration can be achieved at the design stage ut problems do arise here because each project is inevitably by its own goals. A myriad of other unknown decisions for the same area may also be being taken by multiple other actors. Thus the key area of unifying potential is in the knowledge base that guides these multiple decisions, and the creation of shared processes of area appraisal present the opportunity for continuous creation and development of this foundation for systemic integration. *"Context and site analysis are vitally necessary…"* (Punter, 2007, p. 185).

5. Glimpses of potential?

Despite the weak integration of decision making in practice there are glimpses of potential, for example Ellin (2010) has described work in Phoenix where students from several disciplines work under a philosophy of 'Integral Urbanism'. Design Review processes (CABE, 2009) Building for Life assessments (CABE, 2008) and Quality Review (Cowan et. al. 2010) are bringing more systematic approaches to project evaluation. Village Design Statements have also shown how they can play a part in reversing '…the erosion of local distinctiveness…and involving local communities' (Owen, 1999, p.41). The work undertaken by Yorkshire Forward and the Scottish Executive in community engagement where appraisal underpins debate and development of Town Charters, see Figure 8, also deserves recognition.

The transdisciplinary nature of these approaches is important but they have no formal place in our normal working or statutory approaches; they are optional. However they do direct attention to local places and communities and the potential of engaging with people in developing a shared place specific knowledge base would integrate actions holistically. This would facilitate but not control; help to deal with multiple incremental changes while stimulating innovation or preservation; and mediate conflicts between spatial scales of interest as well as multiple actions and multiple actors.

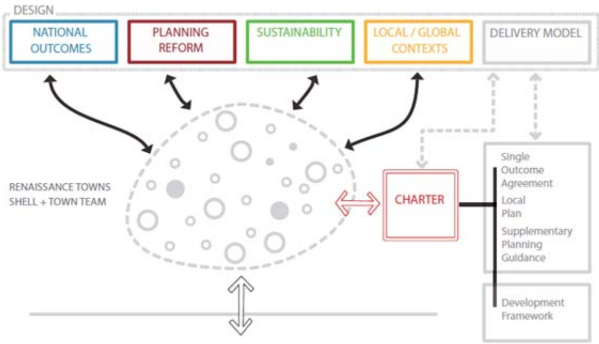

Figure 8: The place of Town Charters in relation to the spatial and instruments of delivery. (Reproduced by permission of Urban Design Skills, London).

The special expertise of the built environment disciplines is developed within the context of a shared interest in the management, development and protection of that built environment, thus it is the places that are paramount if they are to achieve added value and integration between them. As Kostoff (1992, p. 8) observed *"Urban form is…the matrix within which we organize daily life…"* Clearly any intervention in the built environment is complex, and it is only by appreciating the ways in which places develop and the ill-defined rules by which they change that we can have a positive influence upon how they can be developed in the future. This is equally so in historic places, which have often evolved in the most heterogeneous ways; planned settlements, where evolution and change inevitably bring new pressures and directions; places experiencing economic and physical decline; and in the rapid urbanisation of the developing world. The suggestion here is that there are practical ways that shared appraisal of places can contribute to integration between built environment disciplines. However to succeed more deliberate and integrated approaches to situated analysis are needed. This places processes of appraisal and engagement at the heart of the whole process.

6. Borders and boundaries

The borders between disciplines, professions, and institutions and the temporal relationships between them are significant and raise key considerations for 'professional' and adult learning. Here andragogical approaches (Knowles, 1980, 1984), where context and enquiry may be more effective than pedagogical instruction, disciplinary and professional knowledge boundaries are central to the learning object (Webster, 2008). This andragogical dimension is critical if we are to *"…learn not only to be fluent across disciplinary boundaries but also across research and teaching boundaries"* (Frank, 2005, p. 3). It is therefore important to reflect upon the nature of these boundaries within which disciplines develop 'special' knowledge and skills sets, and within higher education where boundaries are imposed by the way that knowledge and skills are valued (Lees, 2007). The attitudes of academics and institutional structures themselves create intellectual boundaries between teaching and research (Frank, 2005) and it is common to find areas of expertise organised into "highly specialized areas of knowledge and traditional disciplines" (Cortese, 2003, p.16). These boundaries extend to the value placed upon theory and practice; principles and application and values themselves. While these 'gaps' have already been recognised as problematic there is another less recognised cleavage between, and within, disciplines that deserves attention. It concerns the relationship between Strategy and Action; between Policy and Prescription as illustrated in Figure 9. This critical boundary exists between the strategic concerns for the longer term and wide scale, and the more immediate concerns of the implementer. Strategy and policy must be concerned with key principles and performance criteria, while implementation and action require precise prescription and specification. Each requires a special and quite distinct mindset which must interrelate over time if it is to achieve added value and synergy.

The strategy and action boundary is transdisciplinary and our challenge is to critically analyse the foundations that should underpin action; the brief before the design; the programme before the contract; and the policies before the programme. The wide range of scales at which development can occur, from the simple shelter to the new city, from the new road to the protected environment, are often neatly separated in our disciplinary theories and practices. However if we consider places holistically, this convenient division is counter-productive because in places the parts are inextricably part of the whole.

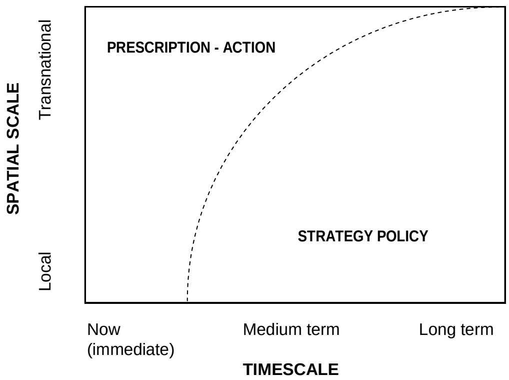

Figure 9.
The strategy-policy/prescription-action 'border.'

7. Action research: Curriculum development and delivery

The two major strategies for interdisciplinary learning have been the focus on commonality between disciplines and the focus on the boundaries between them. A third focus proposed by Chapman (2009) is upon space and place as the opportunity for collaborative learning among built environment professions. This proposed that place based problem and project activities would support both multidisciplinary learning and transdisciplinary work beyond those disciplines to engage with broader societal processes.

As previous attempts at such integration have generally failed; arguably because they adopted over-simplistic approaches uncritically and unreflectively; it is proposed that new research is needed to systematically test some relatively simple conceptual. This would in itself develop an action learning process for staff as well as students by engaging with places and issues with the intention of integrating interactions and outcomes (McGill and Beaty, 1992). The opportunity to exchange and share perspectives would provide the key ingredient of interdisciplinary work (Cooper, 1997). Examples of this sort of exploration are few in practice although Walker (2005, p. 38) has employed 'Land-scape' as a focus for trans-disciplinary learning. While this has been fairly limited in the range of disciplines it significantly focused upon *"…the learning process rather than the production of an object-orientated solution"*.

Webster (2008, p. 1) has argued that the "…transaction costs of change…limit the scope for significant curricular leaps" and that "university teachers might be better able to manoeuvre at the edges in the general direction of greater interdisciplinarity". But will this action at the edges really lead to the transformative action needed? Here it is argued that what is needed is a focus that is simultaneously central to each discipline and on the edge of each discipline. The focus suggested here is upon 'places' as these offer the opportunity for exchange and translation between disciplines and the basis for coming together with diverse purposes but a unified aim: successful sustainable places. Collaborative appraisal of places can provide a focus of study that is simultaneously central to, and at the (leading) edge of, all disciplines and of importance to stakeholders. Sharing appreciations of place and context, initially independent of purpose, would be challenging but intrinsically integrative. When moving on to tackle problem definitions and resolutions it is the context of place that will provide the vital common ground.

Draft Research Framework: Place-making and integrated development studies

An action research framework for the evaluation of alternative learning and teaching requires careful and collaborative and interdisciplinary development, but some of the potential ingredients are outlined below;

<u>Comparative evaluation of learning vehicles.</u>

1. Place based and place-making focused learning vehicle.
2. Project based and development orientated learning vehicle.
3. Problem definition based learning vehicle.
4. Problem based learning vehicle.

While in some learning vehicles students may initially be presented with a quite unstructured problem, it would be situated in a very tangible place. Students would be supported in the process of problem framing and analysis at various spatial, temporal and sectoral 'scales', from which it would be possible to test whether they could find points of departure from each other according to the particular aspect of the space/place they are studying. In this students will "…see on (their) own behalf…" (Dewey, 1974, p. 151, Schön 1987, p.17) and develop knowledge that is both specific to the scale that they are working at, as well as how this relates to those working at other scales. Appreciation of the differences in theories, language and values in play would enable exploration of the ways these can be mediated.

<u>Comparative evaluation of interdisciplinary student and staff interactions.</u>

1. Mixed interdisciplinary team based learning processes.
2. Role playing interdisciplinary roles in team based learning processes.

One variation on interdisciplinary team working might entail disciplinary role play in which students from each discipline are invited to adopt the role of another discipline in undertaking the place based problem exploration. Each student could be guided by a role descriptor which might be prepared for them by the students of the discipline they are adopting. This approach would address asymmetrical discipline cohort sizes, enabling fully balanced interdisciplinary groupings to be formed in any body of students. It may also allow further disciplines and interests beyond those represented in the courses directly involved to be role played in the chosen scenario.

<u>Comparative evaluation of teaching and assessment strategies.</u>

1. Module based formative and summative assessment of the learning activity (Credit rated).
2. Field study based learning activity with formative and summative assessment Credit rated).
3. Field study based learning activity with formative assessment (Not credit rated).
4. Independent field study based learning activity (Not credit rated).

At this stage it is proposed that the focus would be upon interdisciplinary interaction and synergies between although multidisciplinary development will be sought within the disciplines, and opportunities for wider transdisciplinary engagement would be sought in future stages of research (see Winder, 2003).

<u>Some key research questions</u>

- What are the positive and negative implications of using each of the approaches?
- Can added value and synergies be achieved and what are they?
- Are there any perceived or demonstrable disadvantages of working across borders?
- Can any tools, methods or instruments, be identified that add synergy or value?
- Can integration and synthesis be achieved over time and between cohorts? If so how?

Possible methods of evaluation could involve student engagement and feedback, including in-depth discussions both individual and small group; reflective assessments; practitioner engagement and wider community and holder engagement

8. Conclusion

The diversity of actors and the multiple activities that occur daily render the achievement of 'integrated outcomes' difficult in practice and a key question is how can greater integration be promoted in these dynamic and discontinuous situations? The conclusion of this paper is not that contextual analyses are important as this has been well established in each discipline; it is that integration of this analysis and problem-framing between disciplines is an essential precursor to any possible interdisciplinary integration. It is this that has the most transformative potential in interdisciplinary built environment education. This advantage of a physical reality; the uniqueness of the place; and critical questions about the options for its future would provide the focus for interdisciplinary engagement and integration. The approach would not merely be concerned with interdisciplinary relations within the built environment, but also consider the transdisciplinary relationships with a wider economic and societal context (Cuthbert, 2007). The challenge for built environment education is to explore curricula and learning activities that enable student to develop this new knowledge through active learning and shared explorations: between disciplines, and in the context of the wider environmental and socio-economic interests. Thus built environment education can be developed as a 'social practice' which captures the 'ideas' of participants collectively in a process founded in appreciation of the built environment as the context of our lives. More effective integration of analytical and appraisal techniques would provide a knowledge base which would explore the uncertainties and risks identified by Gann and Salter (1999) while fostering interdisciplinary working inherently. The development of a strong and shared knowledge base would naturally form a strong platform for debate and a lively heterogeneity of decision-making and actions, reducing inter-professional conflicts, if not eradicating them. This is a significant point of departure but by engaging with places the built environment disciplines could together become enablers of long term processes of improvement. The challenge is to make systemic improvement the rule not merely in our high profile centres and prestige projects but also for the many ‘non-places’ where no one appears to have responsibility.

The difficulties faced are complex and include the intrinsic discontinuities between the instruments used in the built environment disciplines; differences of disciplinary focus and practices, and the challenge presented by the reality that most change in the built environment is driven by multiple and disconnected actions. Despite these obstacles it is clear that more could and should be done to overcome them. In this the structures of the curriculum and the philosophy of programmes are important, but it is vital that the framing of learning activities enable students to develop deeper appreciation of the interrelationships between diverse actions in space, time and purpose in the actual places that are our built environment. Thus what we are engaged within built environment education and practice requires engagement in a systemic process, rather than simply a series of specialist acts.More effective integration of analytical and appraisal techniques, through diverse but systemic multi disciplinary work and public engagement, could provide a knowledge base which would foster strategic development planning and place-making inherently. Adopting specifically situated learning models in order to develop collaborative interdisciplinary approaches to site analysis, area appraisal and problem definition would go beyond a technical approach to sustainable development to address deeper qualities and values in real places. The deeper appraisal process suggested would inherently foster this discourse, developing much stronger bases for framing plans and informing decisions.

This may not be seen as a high priority within the built environment academy, and it might also attract opposition, from the professional, disciplinary and institutional barriers discussed above. It is also likely that some will argue that there is no space in their curriculum as all the time is needed to achieve interdisciplinary depth, and to produce the oven ready practitioners demanded by employers. In practice it is likely that the call for more systematic appraisal of the qualities of places as they exist will be accused of lacking real or immediate purpose and be costly in time. It will also be opposed by those interests that thrive upon uncertainty, fearing that better appreciation of local qualities of place would close loopholes and enable local people to guide the nature of change in their areas more effectively. In practice however the potential savings in time and contention later in both design and implementation stages are great and the clear benefit would be commensurate reduction in doubt and uncertainty and more effective synergy between agencies and policies. As Healey (1995 p. 254) has observed ‘…integrating potential depends upon the way (a plan vision or knowledge) captures the ‘ideas’ of the people concerned and its ability to guide subsequent decisions…’

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Personalising teaching and learning experience of built environment students in large groups

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Abstract

One of the persistent problems in the higher education sector is the perpetual predicament of teaching students in large groups. Despite passing over the mass production paradigm in manufacture and service industries, higher education has not yet been quite successful in leaving this paradigm behind. Although theoretically the structure of higher education sector has undergone fundamental changes and the technological advancements support every movement in right directions, there are yet practical problems to overcome on this way. Teaching students in large groups as far as vocational courses are concerned becomes a very critical task and highly prone to disastrous failure, if the practical applications of the taught subjects are not fully taken into account. The problem is even more conspicuous where the concerned group is a blend of students on different courses with allegedly different sets of expectations, preferences, priorities, needs, and wants. Added to these complexities are the learning styles of the individual students.

Funded by the Centre for Learning and Teaching, University of Brighton, this research project was designed to gauge the needs and the practical possibilities for personalised learning and teaching logs for individual learners in large groups.

The paper reports on partial findings of the research project. It first of all introduces the concept of customisation and personalisation in their context of origin. Then the critical review is expanded to the application of personalisation in learning and teaching environments by highlighting the individual elements in customisation of education. Setting out the module context, the paper then introduces an industry standard test of learning styles to cross-reference the individual preferences with what in particular is required for each course from the students' point of view. It finally concludes with some practical suggestions as well as some executive level recommendations to more efficiently plan, allocate resources, and carry out teaching large groups for achieving higher satisfaction levels.

Keywords: Teaching large groups, Customised teaching, Personalised learning experience, Learning styles

1. Introduction

One of the persistent problems in the higher education sector is the perpetual predicament of teaching students in large groups. The problem arises as a result of limitation on resources – financial, staff time, and space – and can be exacerbated by variation of demography of the students on a course or a module across different courses. However, this problem is not limited to this level of application and expands all the up the systemic organisation in higher education.

Higher education forms a vast part of service industry. It shares many of the common characteristics of this sector yet refuses to lend itself fully and completely to the mainstream features shared between other major members of the service sector. Despite passing over the mass production paradigm in manufacture and service industries, higher education has not yet been quite successful in leaving this paradigm behind. Although theoretically the structure of higher education sector has undergone fundamental changes and the technological advancements support every movement in right directions, there are yet practical problems to overcome on this way.

Teaching students in large groups has always been a challenge in its own in terms of managing the class, keeping the pace of teaching and learning and ensuring a satisfactory level of engagement of the students. This will be added by some additional concerns when teaching in vocational courses is under focus. As far as vocational courses are concerned, teaching large groups becomes a very critical task and highly prone to disastrous failure, if the practical applications of the taught subjects are not fully taken into account.

The problem of teaching large groups is even more conspicuous where the concerned group is a blend of students on different courses with allegedly different sets of expectations, preferences, priorities, needs, and wants. Added to these complexities are the learning styles of the individual students, ethnic backgrounds which is reflected in individual understandings of higher education, its application and the relationship and tasks of the tutor’s and the student’s.

With a very basic epistemological analogy between the higher education and other service industries, and between the involving variables in this problem on either side, an ultimate solution to this problem would be mass customisation of learning and teaching. This shows a promising shift in higher education towards offering a more efficient service on the service provider’s side as well as a better value for money on the customer’s side, but like any new approach comes with its own challenges and problems.

2. Review of existing literature

2.1 Mass customisation and personalisation

Customisation was first coined by Stan Davis in 1987. In a chronicle of the production paradigms it succeeds mass production. However, as a paradigm it advocates combining craft production with mass production, guaranteeing to maximise benefits of both (See Pine 1993; Pine and Gilmore 2000; Reichwald and Piller 2002; Tseng and Jiao 2001; Tu *et al.* 2001, among the others). A general overarching definition of mass customisation can be 'offering individually customised products and services at a mass scale', which in a more sophisticated form means, 'meeting each customer's individual wants and needs at a cost comparable to mass produced goods or services' (Da Silveira *et al.* 2001; Huang *et al.* 2008; Liu *et al.* 2006; McCarthy 2004; Pine 1993; Piroozfar 2008).

Despite many systemic evolutions and, strategy and application advancements during the recent years many researchers believe that customisation still remains intact as a 'strategy to create value by some form of company - customer interaction at fabrication/assembly stages to create customised products with production cost similar to those of mass produced products' (Kaplan and Haenlein 2006). Some others such as Vesanen and Raulas (2006), on the other hand, subscribe to the idea that customisation is an element of personalisation. With no intention to argue for or against one or the other, in this research we also build our discussion upon the idea that personalisation has different phases i.e. 'customer interactions', 'analyses of customer data', 'customisation based on customer profiles', and 'targeting of marketing activities'; and that they are interlinked.

2.2 Mass Customisation and Personalisation in Education

Although it can be argued that education is no exception from other service industries in application of what was declared as a paradigm shift by Pine (1993), there is very little evidence to support the application of mass customisation in education. There is research which demonstrates the application of customisation in the higher education (Fried 2008; Gabriel *et al*. 2007; Mulder 2005; Nistor *et al.* 2010; Waslander 2007), but there is still need for more systemic research in this area. Mass customisation in education allows catering for the student's individual needs, skills and interests. Rippel *et al.* (2009) believe that not only does this lead to a higher motivation for the students but it also facilitates a better and holistic individual education and deep learning. Nistor *et al* (2010) suggests that the implementation of mass customisation in teaching and training requires a view of the production cycle.

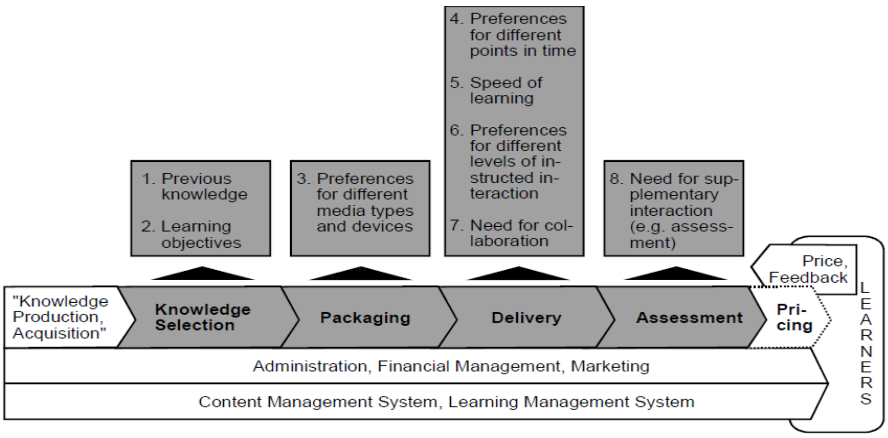


Figure 1: Customisation along the Education Value Chain (Hutzschenreuter 2002)

With a ‘production value chain’ concept in mind Hutzschenreuter (2002) declares that there are different areas along the education value chain around which customisation can take place (Figure 1).

3. Module context

The selected module for this study is BE135: IT and Study Skills. It is a first year module and is worth 20 credits. It is delivered over an academic year consisting of two semesters in the School of Environment and Technology, University of Brighton. The target audience is formed of foundation (FdSc) and BSc students in architectural technology, building surveying, construction and project management. There were 123 students enrolled for the module in 2010-2011 academic year.

The module consists of two different parts; IT and study skills. The study skills cover personal and soft skills including effective strategies for academic reading, time management, presentation skills, preparation for exams, etc. The IT covers IT skills for academic and professional development. Academic IT skills consist of what the students need for their academic studies in university such as online data mining, use of library and archive resources as well as preparing reports and referencing using relevant software packages. The professional skills concentrate on a professional, industry standard CADD (Computer Aided Drafting and Design) package (Autodesk AutoCAD) and an environmental assessment software package (IES).

This study aims to gauge teaching and learning of the CADD package. However, from time to time, the findings and results of this study are overshadowed by the other elements of this module as the understanding, at some particular points, was that this is an assessment of the module. For the content coverage of the module, the number of students and limitations on space, resources and staff, the CADD is delivered to three groups of 35-45 students in two-hour workshops every other week (the workshops alternate between IT and study skills every week) totalling 8 CADD workshops altogether. The assessment is formed of class assignments as well as two coursework, one at the end of semester one and the other at the end of semester two.

4. Methodology

Coffield *et al.* (2004a, 2004b) identify five families of learning styles and evaluate in detail 13, as per their account, influential models, looking at both studies where researchers have evaluated the underlying theory of a model in order to refine it and empirical studies of reliability, validity and pedagogical impact.

For this study Index for Learning Styles (ILS) was selected to map the learning styles of the first year built environment students at the beginning of the academic session. ILS was deemed a practicable and worthwhile tool for this study because it is an open access on-line tool for evaluation of four dimensions of learning style, i.e. active/reflective, sensing/intuitive, visual/verbal, and sequential/global. The other reason for this selection was that the model, which was formulated by

Richard M. Felder and Linda K. Silverman of North Carolina State University, aims to assess teaching and learning in engineering education.

The online survey was set and used for preparing and analysis of the pre- and post-module questionnaires. Participation in the surveys was voluntarily, anonymous, and confidential. There was no assessment element attributed to any of the questionnaires or the additional experiments. The pre- and post-module questionnaires were designed to monitor students' understanding, expectations, needs and requirements before they experienced this module and after that. It was expected however, that with no actual personalised element structured in the delivery of this module, both pre- and post-module questionnaires call for such a necessity. The method used for this part of research chiefly relied on pure quantitative methods while the additional learning and teaching experiment which meant to monitor the effectiveness of individually tailored solutions for different types of learners, was mostly based on qualitative methods, although it also used a questionnaire at the end of each experiment. The additional experiment was designed with careful considerations about limitation on resources and staff time and workload and was meant to use an approach comparable to Duray *et al.'s* 'Assemblers' model with the least possible increase in face-to-face contact time with students (2000).

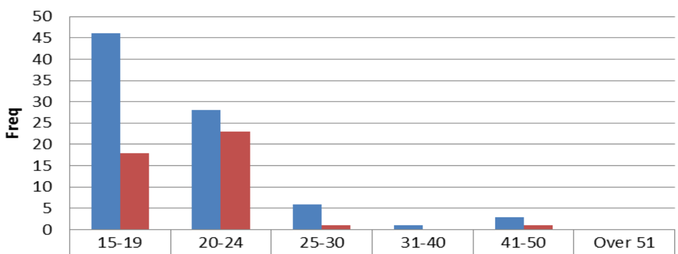
This paper will present partial findings of the quantitative study. The findings of the qualitative section will be discussed separately later.

5. Findings

Two questionnaires were designed and surveys were conducted at the beginning and end of the module. The findings from these surveys are discussed in the following sections. A total of 86 responses were received for the first survey, compared to 46 for the post-module survey. There were a total of 123 students enrolled on the module.

5.1 General

Early on in the study, it was important to establish the general profile of the sample population. In general, 94% of the students are undertaking an undergraduate degree for the first time, while the remainder held a previous degree on a non-related subject.



	15-19	20-24	25-30	31-40	41-50	Over 51
Pre	46	28	6	1	3	0
Post	18	23	1	0	1	0

Figure 2: Age groups of the students enrolled in BE135

Starting with the age group represented in the responses; the age profile of the responding students was representative of the ages represented in the entire population; students registered on the module. Most of the students are aged 15-24 years old. 55% of responding students were aged 15-19 years old in the pre-module questionnaire, compared to 42% at the post-module survey. 33% were aged 20-24 years old at the pre-module study compared to 54% in the second survey. A small minority are aged 25 and above (see Figure 2).

Numerically, more FdSc students engaged with the study compared to the other courses represented in the module. Fewer students completed the post-module questionnaire compared to the pre-module survey. However, participating in the study was not a compulsory requirement.

A cohort of 120 to 140 forms the class size in this module each year. There are some lectures on use of library, online search for academic resources, study skills, referencing and use of EndNote which are delivered to the entire class in big lecture theatres. The computer workshops however are delivered to a class size of 35-45 students at a time, due to the size of computer labs, limitation of the support staff at hand at any particular time and also concerns about the quality of the delivery of the workshops. This means each workshop has to be repeated three times identically to cover the entire first year of the built environment students. 75% of the students said that they had previous experience of learning in large groups; of which 19% said that they had a neutral opinion about it, 17% liked or loved their previous experience of large class sizes, 3% said they disliked it, 5% gave other answers, and the rest did not rate their experience.

5.2 Teaching

The module was delivered in three identical sessions Mondays 2-4 pm, Mondays 4-6 pm, and Tuesdays 4-6 pm. When asked about preferences for when lectures are held, majority (53%) indicated that they preferred late morning lectures held between 11am and 1pm. The next preference (26%) was for early morning lectures from 9-11am.

IT forms the larger components of the module; which is predominantly designed to equip students with the elementary IT skills they require at the early stages of their study. Students were therefore asked to describe how their perception of technology will influence their teaching expectation.

The general feedback was that there was a general awareness of technology but that the approach to teaching should still be as traditional with support provided by members of staff instead of heavy reliance on high-tech teaching aids. Students still preferred direct face-to-face teaching and easy access to support staff as and when required (Figure 3). This would put forward a serious challenge, should heavily technology-reliant solutions such as Sigala’s (2002) be envisaged to be followed.

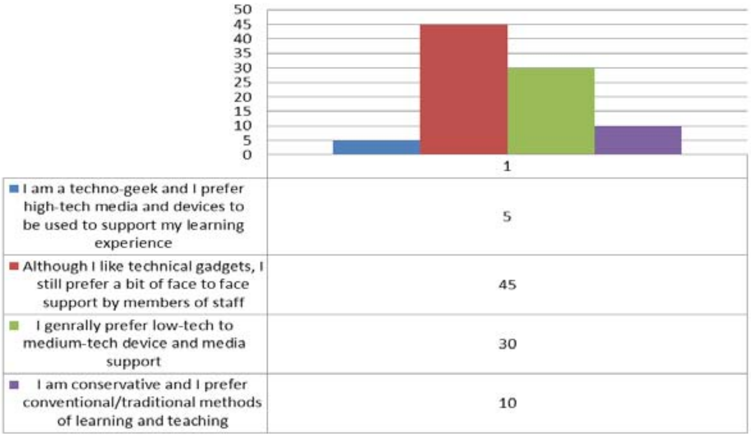


Figure 3: Preferred level of technology employment

To further support the previous finding, majority (56%) preferred workshop-type teaching sessions while 41% preferred the traditional approach of the teacher instructing the students (Figure 4).

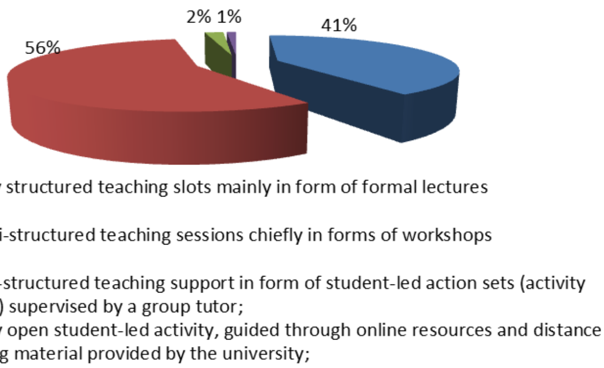


Figure 4: Teaching delivery preference

This is interesting because for the nature of the module i.e. teaching software packages etc., a mixed teaching approach of lectures/demonstrations and one-to-one support was considered more suitable for the delivery of the module.

5.3 Learning

To provide context to the findings, majority of the students said that their learning pace was average to fast (45% and 41% respectively) at the beginning of the module (Figure 5).

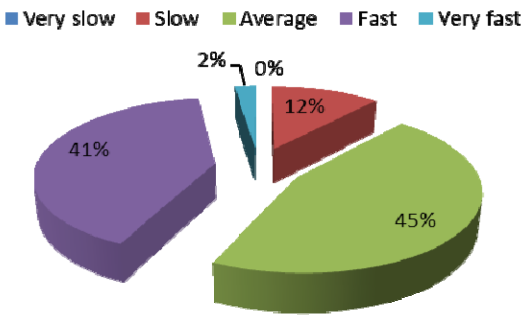


Figure 5: Typical learning pace as assessed pre-module

At the end of the module, majority (50%) said the teaching was well paced or adequate and suited to their learning pace. In addition, 21% rated the pace average. 19% rated it poor and 10% said that they simply could not keep up. The main problem appeared to be the mode of delivery and quality of teaching support provided (Figure 6).

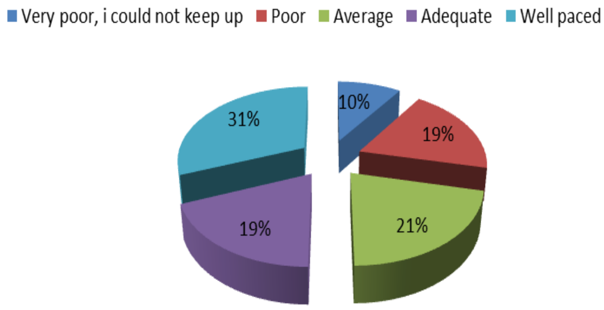
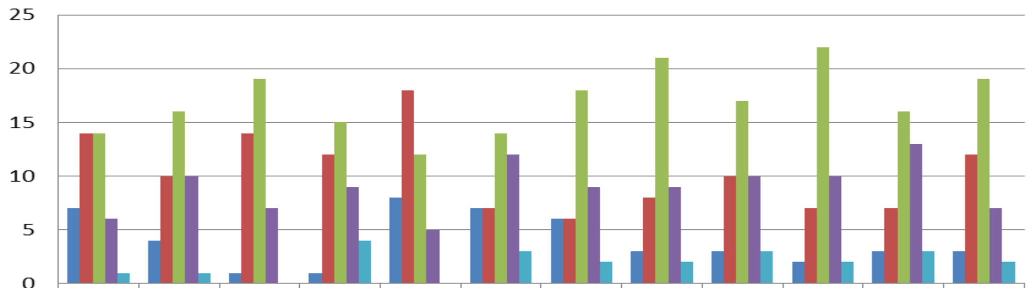


Figure 6: Learning pace as assessed at the end of module

Both self-assessed learning pace pre-module and the one assessed post-module in correlation with the teaching pace in the IT component of this module, prove that the variety of learning styles, paces, preferences and needs, require a more personalised approach to learning and teaching this particular module.

5.4 General comments

Some students considered that the pace was too fast for them. Others indicated that the layout, location and setting teaching rooms were vital for improving learning outcomes. Others will like teaching materials provided in more accessible formats. Overall, students were asked to rate 11 quality criteria for the module. Rated medium to low were; quality of lectures and tutorials, the value of class time as well as class discipline. The quality of additional support was also rated low by a majority of 18. Rated medium to high were; the course material provided, the assessment method, retaining skill and knowledge, links to other modules. The value of the module for the development of general knowledge and skills, and subject coverage was rated medium. Overall, the quality of the module was rated medium to low (Figure 7).

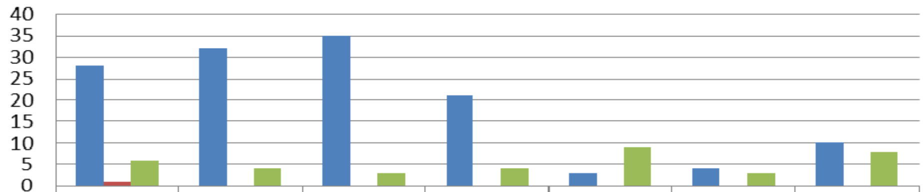


	Lectures/Tutorials	Subject coverage	Class time	Class discipline	Support provided	Course materials provided	Assessment method	Acquiring skill/knowledge	Development of skill/knowledge	Retaining skill/knowledge	Link with other modules	Overall learning experience
Very low	7	4	1	1	8	7	6	3	3	2	3	3
Low	14	10	14	12	18	7	6	8	10	7	7	12
Medium	14	16	19	15	12	14	18	21	17	22	16	19
High	6	10	7	9	5	12	9	9	10	10	13	7
Very high	1	1	0	4	0	3	2	2	3	2	3	2

Figure 7: Overall Quality

Explanations given to support these ratings were that feedback from lecturers should be better and timely. The assessment criteria should be clear, and the pace of lectures should ensure that previous concepts are understood before introducing new ones. The support staff should be accessible for tutorials, the workbook is good but requires substantial improvement to minimise omissions, contradictions and confusion. Instructions should be clear and consistent too.

Specifically for the module and at the end of the academic session, students would also prefer more teaching time and tutorial support. They would have liked more time focussed on the specific skills that they needed to learn rather than the general ones. They will also like to have had clearer and accessible instructions about learning outcomes, coursework and other assessments (Figure 8).



	teaching time	support/follow-up time	detailed instructions	specific skills	student-led activities	general skills	tutor-led activities
More	28	32	35	21	3	4	10
Less	1	0	0	0	0	0	0
Appropriate	6	4	3	4	9	3	8

Figure 8: After-Preferences (The module in particular)

Provided that the delivery of this module was vastly overshadowed by the limitation on staff both at the start and more half way through the year as a result of a lecturer leaving the school, this required some modification in the content and context of delivery. Apart from the staff shortage, all the quantitative and qualitative data collected throughout the year using pre- and post-module surveys proved that all the students seek for more tailored/ personalised teaching and learning support to help them develop the set task and required skills in a more individual manner.

6. Conclusion and closing comments

This limited experience, which was designed to highlight the need for and importance of personalised approach to teaching and learning in higher education, like any other case-based experience, came with its limitations and restrictions. Provided that there was very limited element of personalisation and customisation built into the delivery of this module, its scale, the variation of the audience and the variation of the subjects to be covered under the umbrella of this module, the findings are still generalisable into teaching and learning in large groups both in general and in particular in the built environment disciplines. Here are some conclusions and executive recommendations which might prove useful when teaching large groups:

- Although this might contradict strategies of most of the higher education institutions especially in tight financial atmosphere, students in the HE sector in UK would like to see an element of individuality in their courses to be convinced that they are getting the value for their money. This has a proven record in other mega-modules offered in second and third year in School of Environment and Technology, University of Brighton.

- Engagement is a crucial factor and very prone to be missed during lecturing large groups as a result of different learning styles and pace.

- There are possibilities to build some personalisable/customisable elements into such modules with huge target audience. This was tried in this research but quantification of results is not possible due to low number of participants. A further qualitative evaluation is required to come to a more objective conclusion for building such elements into the module.

- The amount of one-to-one or direct tutorial support is a key to develop a more tailored package for individual students specific to their learning needs and preferences.

- An established monitoring e.g. personal tutoring system can help facilitate building up a database of the individuals' learning style which can then feed into personalised approach to learning and teaching.

- A very careful survey of vocational gaps, needs and requirements will also help develop a top-down approach for a more realistically customisable learning and teaching solutions in vocational courses.

As the final closing comment it is worthwhile to bear in mind that customisation and personalisation at a module level might prove very difficult to achieve but it definitely is not unachievable, should careful consideration regarding time, space, the content and the context and the target audience be taken into account well in advance and perhaps at the stage of planning and development of the course curriculum, module descriptor and learning outcomes/objectives. It might prove much easier to design and deliver a fully personalised degree course with a choice of a variety of available modules for the recipient of the degree to choose from. This however, is subject to further investigations.

7. Acknowledgements

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Pedagogy for Teaching and Learning in a Professional Discipline

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Abstract

In order for students in any professional discipline to be able to apply classroom knowledge to practice, teaching and learning have to move away from the conventional teacher-centered to student-centered approach as well as a class atmosphere in which students can learn by doing. However, practicality should not equate narrow vocational learning in the forms of apprenticeship. The learning of students must be based on principles so that they are able to perform professional tasks in an informed manner. The paper is aimed at describing and analyzing a pedagogy for teaching first-timers quantification and measurement of building works and cost estimating. The paper describes the underlying theoretical perspective of the approach as well as how it has been implemented. The study argued that the pedagogy will give students a sound theoretical and experiential knowledge needed to prepare them for work when they graduate. The pedagogical implications for students' learning and the potential challenges are described. It also presents some findings from student experience survey. Future research directions are highlighted. The knowledge developed can serve as a generic framework for developing a teaching and learning pedagogy in any professional discipline.

Keywords: cost estimating, learning, measurement, pedagogy, professional discipline, quantity surveying,

1. Introduction

The challenge faced by students graduating from a professional discipline is that they must be able to immediately apply what was learnt in class to real world for them to be able to easily gain entry into the competitive job market. Thus there is need for a teaching and learning approach that stimulates students to learn the principles underlying the discipline as well as the application of the principles to practice in accordance with established professionals standards. In order words, If professional disciplines within universities must produce graduates who, upon graduating from the university, can immediately put to work what was learnt in class there is need to adopt pedagogy that facilitate learning by doing. There is also need to constantly reflect on teaching and learning approaches with the aim of improving their implementation and thereby improving student learning. Gow and Kember (1993) argue that all teachers have some theory of what teaching is and, even if they are not explicitly aware of that theory, their theories deeply affect the kind of learning environment they create in their classrooms. Wise and effective teaching is not, however, simply a matter of applying general principles of teaching according to rule; they need adapting to each teachers' own personal strength and teaching contexts (Biggs and Tang, 2007). Thus one of the ways to improving teaching and learning and becoming a better teacher is to become 'a reflective practitioner' (Schon, 1983). This paper describes and reflects on an approach being used for teaching first-timers measurement and quantification for building works. The objectives of this paper are:

- to describe a pedagogy used in teaching the first-timers measurement and quantification at the Faculty of Architecture, the University of Melbourne.
- to review the underlying theoretical basis for adopting the teaching approach
- to reflect on the pedagogical implications for student learning of the approach.

The knowledge developed can be used to developing and implementing pedagogy for teaching and learning in any professional discipline.

2. Research Methodology

This paper describes and analyzes a pedagogy for teaching first-timers quantification and measurement of building works and cost estimating. The paper describes the underlying theoretical perspective of the approach as well as how it has been implemented based on evaluation and applications of theories on teaching and learning and the author's experience as a learner in quantity surveying for 7 years and now as a teacher for 16 years. Due to space limitation, the paper also presents a summary of the findings from the 2011 University of Melbourne online students experience survey for the subject in measurement of building works and cost management which assesses students' learning experiences.

3. Context and Challenges

In order to prepare students for future work life, ‘measurement of building works’ is one of series of subjects aimed at providing opportunity for students to gain the knowledge and skills of measurement and quantification for different building components when detailed design is available. The purpose of quantification is to enable cost estimating. It is a core subject for third year students in the construction major of the Bachelor of Environments (BEnv.). It is also available as breadth subject for students in the architecture program. A version of the subject titled ‘Cost Management’ is also available in the first year of 300 points Masters in Construction Management within the Melbourne School of Design. The 300 points Masters has been designed for students from non construction management background.

In year 3 (final year) of the in the BEnv, our students have already identified their major and are most likely to have decided (or are in the process of deciding) on a study area for their professional Masters which follows after completing the BEnv. For those who prefer to work prior to pursing their master degree or those who prefer to take-up part time employment in construction, the second and final year is also a crucial moment for them to gain some practical and professional skill that they can immediately put to work upon graduation. Measurement and quantification of building works is a subject that will help them in that regards. It will equip students with skills of measurement and pricing including elementary measurement for bills of quantity, building-up unit rates, and pricing of measured work as well as a basis upon which students can learn how to prepared construction cost plans. While it is not possible to cover all aspects of measurement for all types of construction projects, the subject focuses on measurement and pricing of a simple residential building being the first subject providing student with such skill. Hence, it is an essential subject for our students. Additionally, the subject is closely connected to what our students will be learning in the future. Although it is a year three semester one subject, the skill developed by students is a foundation to semester 2 subjects - ‘Construction Cost Planning and Economics’ and ‘Project Planning Studio’ (a capstone subject). Also, the subject will inform students learning in ‘Construction Measurement and Estimating’ – a core subject for students during the second year of their professional masters where students will be required to quantify and estimate the cost of projects using computer software with BIM as a platform as well as analyze prices of building work items.

The challenges of measurement and quantification (hereinafter refereed to ‘take-off’) is that measurements for building quantities have to be based on the building drawings (or the design) as well as in accordance with the standard method of measurement of building works (hereinafter referred to as ‘the SMM’). Thus ‘taking-off’ is the process of measurement of quantities of building works from drawings and booking them in specific order and method and in accordance with the rules and principles of the SMM. SMM is a book of measurement rule. In real world, most buildings are unique and therefore, when preparing quantities for cost estimating, a quantity surveying professional would have to apply the principles of the SMM to different building in different ways. Also the application of the SMM principles and rules to quantification of work for the different part of a building and for the different items of work to be done on the building would vary. For instance, the rules applicable to ‘taking-off’ quantities for Brickwork differ from the SMM rules applicable to taking-off for ‘Roof’. On top of these challenges, the quantity surveyor need to be able to accurately describe different work items in terms of the quality of material and workmanship required in according with the SMM.

The Australian Institute of Quantity Surveyors advises that quantification skill is one of the basic skills leading to a competent quantity surveyor (AIQS, 2005). Even with the advent of BIM, quantification and cost estimating skill will continue to be a basic skill requirement for the quantity surveying professionals. Employers often prefer graduates with practical skills of quantification and cost estimation as well as those who understand the theoretical basis of the field. Incidentally, the quantity surveying is one of the major critical areas of skill shortage in Australia.

To address these challenges within the context described, there is need for a teaching approach that would allow students develop understanding of principles as well as practical skill and ability to apply the principles learnt in any project situation. The approach need to integrate the following (i) construction technology (2) principles of quantifying building works (ii) practice (iii) skills (iv) ICT (v) assessment of the students' understanding of the knowledge as well as the skills required in quantification and measurement.

4. A Reflection on the Conventional Teaching and Learning

In the conventional teaching and learning, learning is completely teacher-centered. It is more of what Biggs and Tang (2007 pp. 151) referred to as 'fill-up-the-tanks' model of knowledge acquisition. It is teacher-centered rather than students'. Students are encouraged to be passive learners. Typically students are given a problem example during lecture. The teacher explains how to work through the example based on a template solution prepared by the teacher. Students contribute nothing to the exercise. They are required to study the worked examples after class in order to grasp the technique for developing the solution. Most students see the teacher as the knowledgeable experts who expound information that they have to absorb and during exams report back accurately (Biggs and Tang 2007; pp 17). Conventional teaching and learning does not require any formal tutorial. Students have limited or sometimes no learning activities that could enable them clarify their thoughts, reflect on the concepts and apply the concepts to new problems. The bulk of the assessment is typically through the end of semester exam. Teaching and learning is piecemeal and fragmented. For example, in quantity surveying discipline, measurements of various parts of a building are done at different times during student's academic life. This is not very helpful in a professional discipline where knowledge requires incremental development over time, and requires integration of the knowledge to enable student effectively apply the knowledge in practice. Also in the conventional teaching, problems used in teaching different but interrelated aspects are different. For example in measurement and quantification, the architectural drawings used for teaching different elements are issued to students differently and piecemeal, and in different semester. Thus, students are taught many interrelated things independently of one another. In the literature, concern has been raised about the extent to which students learning under the conventional approach actively listen, comprehend, organize and relate to the material (McKeachie, 2002).

5. Why the Conventional Teaching and Learning mode is Inadequate in a Professional Discipline – A Theoretical Review

In this section, I examined the reasons the conventional teaching and learning mode is inadequate in a professional discipline. I will examine the reasons around the following themes: (i) differences in the way students learn (ii) The need for students to develop an understanding of the concepts (iii) The need for students to develop technical skill and experiential knowledge.

5.1 Differences in the way students learn

There are the two cohorts in every class and can be described in terms of the learning approaches adopted namely ‘deep’ and ‘surface’ approaches (Marton and Saljo, 1976a and 1976b; Biggs and Tang 2007: pp 22-26). Deep learning is characterized by a personal commitment to learning and interest in the subject. Students adopting this approach set out with the intention of understanding the material, they interact critically with the arguments put forward, relate them to prior knowledge and experience , and evaluate the extent to which conclusions are justified by the evidence (Biggs 2003; Ramsden 2003). Whereas surface approach is the result of students intending to get the task out of the way with minimum trouble, while appearing to meet the requirement of the course (Biggs and Tang 2007: pp. 22). This approach leads to the misunderstanding of important concepts and poor quality learning outcomes (Ramsden, 2003). It involves verbatim recall of what was taught by the teacher rather than understanding the concepts and its application. As pointed out by Biggs and Tang (2007) verbatim recall is sometimes entirely appropriate, such as learning lines for a play, acquiring vocabulary or learning formulae. However, quantity surveying and cost estimating involves application of principles differently in different contexts. Thus surface approach to learning cannot deliver the skills needed by students to perform when they graduate. For these reasons, a teacher needs to discourage surface approach and encourage deep (Biggs and Tang, 2007: pp 26) in a professional discipline. According to Biggs and Tang (2007: 26) good teaching prevents students from using a surface approach by discouraging the use of low level and inappropriate learning activities. Teaching ‘measurement and quantification’ need to make use of a mode that shapes students’ approaches to learning. The mode should help surface learners to adopt deep approach while keeping deep learners on their deep approach. The class atmosphere in the conventional teaching and learning promotes surface learning especially for the group of students who have little or no motivation for their learning.

5.2 The need for students to develop an understanding of the concepts and principles

One of the challenges of student learning in a professional discipline such as quantity surveying is that quantification of works and cost estimating in a professional manner is contextual due to uniqueness of different buildings and differences in practice from country to country. Drawing from Biggs and Tang (2007) work, this would have implication for the way student learn in that teaching and learning involving only functioning knowledge (practicality) without conceptual knowledge (declarative knowledge) would not provide students with the skill needed to apply what was learnt to real world in different context. If students must benefit from their learning, they need to learn concept and principles so that they can apply it in different contexts. According to Biggs and Tang (2007: pp. 136) learning needs to give students the ability to not only perform identical task but also an understanding of the basis for doing it. The conventional mode does not encourage this.

5.3 The need for students to develop technical skill and experiential knowledge

In a professional discipline much of declarative knowledge (conceptual knowledge) is learned not for its own sake so much but to construct a platform for launching informed decision makers and performers (students) into the workforce (Biggs and Tang, 2007: pp 135). Thus developing conceptual knowledge and understanding of principles as well as developing the ability to put concept to work through experience are both critical for students learning.

From a review of the literature, the need for students to gain practical knowledge and know how to put concept to work has its root in John Dewey’s philosophy of education. Dewey believed that experience is the greatest teacher (Dewey, 1897) and as a result students must experience education in context of life. According to Dewey (1938/1997), educators are responsible for providing students with experiences that are immediately valuable and which better enable the students to contribute to society. Dewey (1916) argued that any skill that can be reasonably expected to have value across the life experience of the student can be an important part of the curriculum. Dewey’s work is also related closely to the constructivist theories of learning (Paiget 1967) which argues that humans generate knowledge and meaning from their experiences. Dewey’s philosophy has given rise to many active approaches to learning including the following: Project-based learning (Harris and Katz, 2001): this is a learning approach where students engage in design, problem solving, decision making, and investigative activities. Students work in groups or by themselves and thereafter come up with ideas and realistic solutions to identified problem. These classroom projects are used to assess student's competence on the subject rather than the conventional examination approach. Another active approach is the problem-based learning (Kolb, 1984) where students collaboratively solve problems and reflect on their experiences. The intended outcome of problem-based learning is that students solve professional problems and the teaching requires students go through solving such problems (Biggs and Tang, 2007).

Action learning (Weinstein 1999) approach requires that learners be active in their learning, and not passive recipients of information. Authentic tasks must be performed and the learners must repeatedly perform as expected (Anderson and Armbruster, 1990). Action approach also requires that theories previously learnt must be tested by students for validity by applying it to real situations. Thus, it requires integration of theory and practice and opportunity for student to reflect on their leaning. It also requires that student’s should be involved in the experience together with their peers through collective discussion and dialogue (Weinstein, 1999).

The conventional mode of teaching and learning cannot deliver the technical skills and experiential knowledge required of new graduates in today's employment market. From employers' perspective, it will take too much time for students graduating under that approach to fully integrate into the workforce [especially for students who adopt the surface learning approach]. Since it is a 'fill-up-the-tanks' approach where teachers feed the students with information and where there is little or no formal requirement to put what was learnt into practice, student who adopt the surface approach would develop little practical and experiential knowledge as well as little conceptual understanding. The problem is employers often prefer graduates with practical skills as well as those who understand the theoretical basis of the field. Such students are more adaptable to changes the workplace and in work practices. Thus students' conceptual knowledge needs to be rooted in practice. Being book smart is not enough, a student need practical skills to be competitive among other new graduates in the employment market. In a professional discipline requiring functioning and declarative knowledge there is need to adopt a teaching approach which allows students to put concepts learnt into practice in a repeated and progressive manner. The approach must be student-centered and must involve learning activities that enhances students' participation and facilitates learning. The activities that students work with need to mimic what professional do in real world.

6. A Student-centred Pedagogy in a Professional Discipline: How it Works

6.1 Curriculum: the design

In order to promote 'deep' learning and motivate students so that they are kept engaged to understand the principles and develop technical skill and experiential knowledge, a student-centred pedagogy based on the principles of 'constructive alignment' have been adopted (Biggs, 1996; Biggs and Tang, 2007) to teach a measurement, quantification and cost estimating subject at the university of Melbourne. Constructive alignment is 'constructive' because it is based on constructivist theory that learners use their own activity to construct their knowledge or other outcome. The 'alignment' reflects the fact that the learning activity in the intended outcomes, expressed as a verb, needs to be activated in the teaching of the outcome is to be achieved and in the assessment task to verify that the outcome has in fact been achieved (Biggs and Tang, 2007).

In the subject description for the subject, the learning outcomes were carefully worded using active verbs and are linked to outcomes contained in the national competency standards for quantity surveyors published by the Australian Institute of Quantity Surveyors (AIQS, 2005) as well a reflects those of the Royal Institution of Chattered Surveyors (RICS). The learning outcomes are closely linked to the weekly lectures, tutorials, and assessments. The outcomes are as follows:

Upon completion of this subject, students should be able to:

1. <u>Apply</u> the Standard Method of Measurement (SMM) to quantification of the works for simple buildings.

2. Measure quantities for groundworks; masonry (Brickwork); concrete/reinforcement and formwork; simple timber pitched timber roof; roofing, and finishes.
3. Describe a bill of quantities
4. Produce a bill of quantities for groundworks; masonry (Brickwork); concrete/reinforcement and formwork; simple timber pitched timber roof; roofing, and finishes.
5. Investigate and price measured building work items.
6. Explain the application of computer software to measurement of building works.
7. Demonstrate understanding of the theory and practice of competitive tendering.
8. Explain the role of cost management of building works.

The active verbs (underlined) combines cognitive, affective, and psychomotor domains of learning so as to give the students a holistic education as proposed by Bloom's Taxonomy of educational objectives (Bloom et al., 1971; Anderson and Krathwohl, 2001). They also reflect different levels of understanding required of students.

6.2 Learning activities

The curriculum operated in the following ways: the lectures are interactive and are focused on the principles of measurement and quantification as outlined in the Australia Standard Method of Measurement (ASMM). Some lectures are focused on the principles of measurement for five major elements of a building; coupled with examples showing the application of the principles in practice. Some lectures addressed bill of quantities and build-up of unit rates from the first principle. In each week, the lectures are focused on interaction and discussion with students about the theory and principles and the underlying philosophy of how to apply SMM to quantification of work, including an example of how the principles can be applied in practice. This is different from the traditional approach where lectures are teacher-centered and involved little or no interaction with the teacher and among students. In the pedagogy weekly lectures are followed by a two hours tutorial where students apply the principles that were learnt in the lecture of each week to a building drawing issued at the beginning of the semester. The tutorial activities are thus closely linked to the lectures and they become the assessment tasks. Thus students' knowledge about how to quantify building works in accordance with the Australian standard is assessed for each of five building elements. Also, the integration of the assessment tasks and tutorials activities is also assessed in the form of a final task whereby students are required to produce a bill of quantities and price building work based on their work and knowledge from all the other assessment tasks.

Added to the curriculum design, students are kept engaged by interactive teaching to stimulate learning using some other techniques: first, since the ability to perform measurement tasks depend on knowledge of construction technology, photographs showing building work items to be measured are included on the slides and thereafter the principles and how to measure them in practice coupled with examples and provided. Second, students are involved in peer teaching whereby they are asked to solve a measurement problem on the white board; and third, students are asked a lot of questions during lectures. Because the lecture and the tutorial times followed each other and in the same room, sometimes lectures are interspersed with tutorial activities and vice versa with breaks at reasonable intervals.

6.3 Assessment and feedback cycle

Following Dewey (1897) on the need for students to experience education in context of life, the tutorial exercise and assessment task given to student after each lecture mimics the kind of activities that practitioners do in their professional practice. The problem requires simple answers but certain information are included or excluded in order to make the solution difficult to arrive at. Students do research on a solution to the problem based on the principles learnt during the lecture of that week and based the prescribed/recommended readings and other sources. Thereafter, students formulate a solution during the two hours weekly tutorial by discussing with their colleagues in a small group and also by receiving formative feedback from their tutor during the tutorial. Students develop the solution further in their small groups or individually after the tutorial (depending on whether the assessment is a group submission or an individual submission). The approach is similar to the concept of problem based-learning, project-based learning and action learning which can promote deep learning and is likely to result in better retention, transfer integration, and application of knowledge and lead to higher quality learning outcomes (Ramsden, 2003).

While the students are doing the assessment tasks they have the opportunity to consult with the staff and their tutors in order to receive formative feedbacks on their work. The formative feedbacks are not graded. Students also have the liberty to email their queries. Responses to all queries are compiled and emailed the entire student cohort within 24 – 48 hours. Student are given reasonable time (minimum of 1 week and maximum of 3 weeks depending on the scope of the assignment) to finalize their solution and submit the proposed solution to their tutors (as a group or individually depending on whether the assessment is a group submission or an individual submission).The solution is assessed and graded with summative feedback. The rubric used to assess the students' work is clarified at the beginning of the semester and included in each assignment sheet. The specific criteria for assessing students' achievement of the learning outcomes are clear, valid and reliable to consistently help judge if learning has taken place or not and to what extent across students.

After assessing the students' submissions, one of the best works is selected and discussed with the cohort during the first 15 minutes of the following lecture. Common errors in the submissions are also pointed out. Thereafter the selected model is made available to student through the online learning management system. The cycle is repeated throughout the semester for each learning and assessment task.

6.4 Use of ICT

Turning to the use of ICT, while the traditional quantity surveying practice is based on paper and pen approach to quantification of building works and estimation of cost, the use of computer software is on the growing increase and may likely be the way into the future of our profession. However, the use of computer is 'Garbage In, Garbage out'. Thus learning quantity surveying and costs estimation from the first principle is very vital. The students in this class are first timers to measurement, they are mandated to used pen and paper for their work in the first 3 assessments. The use of computer is allowed in the fourth assignment which involved integration of the first three. In a higher level measurement and estimating subject students' learning is based on the use of relevant software including a BIM platform (Revit software couple with CostX estimating software).

6.5 Linking Research and Teaching

While there has been a mixed view in the literature about research- teaching nexus, the University of Melbourne recognizes that research can inform and enhance teaching and that research-teaching nexus has both explicit and subtle qualities (Baldwin, 2005). This is in line with Principle 2 of the nine principles guiding teaching and learning at the University of Melbourne which is 'an intensive research culture permeating all teaching and learning activities'. According to Stark and Lattuca (1996) effective curriculum design and assessment strategies are central to successfully linking teaching and research in higher education since it is the organizing framework that allows academic staff to determine how they will facilitate and assess students learning in relation to the goals of their discipline. One of the nine recommended ways of nurturing research-teaching nexus is by building small-scale research activities into undergraduate assignments (Baldwin, 2005). Thus an aspect of the pedagogy is research-based. The fourth assessment tasks requires student to not only produce a bill of quantities based on the integration of first 3 assessment tasks but also to conduct a market research and price the bill of quantities. While this does not involve setting up a research problem, it seeks further to enhance student's engagement and active learning as well as develop their capacity to gather useful data, processing the data and make meaning of the data. In practice, market research is an essential part of cost estimating process. Thus the pedagogy enables students to experience what they will be doing in their work in the future when they graduate.

6.6 Managing student diversity and providing explicit support for individual development

As with many universities, the University of Melbourne has a culturally diverse student population, including students from indigenous, international and recent immigrant backgrounds (Arkoudis, 2006). Principle 4 of the nine principles guiding teaching and learning at the University of Melbourne is ''an international and culturally diverse community and learning environment" (James, 2007: pp 9). Arkoudis (2006) stated that there is need to give attention to teaching strategies and approaches to address the specific needs of the different groups of students. Student need to be given opportunities to see how knowledge in different disciplinary milieu is produced and applied, and knowledge transfer experiences that include a variety of opportunities to investigate alternative ways of applying and practicing knowledge.

Related to diversity, one of the challenges of student learning the quantity surveying and cost management discipline is that quantification of works and cost estimating in a professional manner is contextual due to differences in practice from country to country and due to the uniqueness of different buildings. Drawing from Biggs and Tang (2007) work, this would have implication for the way student learn in that teaching and learning involving only functioning knowledge (practicality) without conceptual knowledge (declarative knowledge) would not provide students from different countries with the skill needed to apply what was learnt to real world and to suit their context. Incidentally, there are now a substantial number of students from different Asian countries in our discipline, who upon graduation may return for work in their country. If this cohort of students must benefit from their learning, a subtle internationalising of the content of our subject is critical (Arkoudis, 2006). In the teaching of measurement and quantification, the application of standard method of measurement should not only be learnt in the context of Australia but in a way that allow students to understand the philosophies underlying the standards and how to apply it in different contexts. Thus during the lectures students learn principles of how to apply standard method of measurement to quantification of building works so that they are not only able to perform tasks but also an understanding of the basis for doing it.

In order to support students from different countries, the 2006 University of Melbourne DVC (academic) Summit recommends the following approach for encouraging inclusive practice in teaching learning and assessment: providing equitable opportunities for all students to communicate in the classroom; create an environment which facilitates student interaction, use random rather than self selection techniques for group work to ensure that students work across cultural boundaries and are not isolated, incrementalise tasks and provide reflective feedback so students can develop a foundation in which to build skills and knowledge.

7. Implications for Students Learning and Findings from Students' Experience Survey

Since the lectures, tutorial, assessment and learning outcome are linked; it stimulates the majority of the students to adopt the deep learning mode rather than surface learning approach. While the students are doing the assessment tasks they have the opportunity to consult with the staff and their tutors in order to receive formative feedbacks on their work. The approach to assessments is good because students construct their own solution, work collaboratively and individually as well as interact with the teaching staff (formative feedback) in an ongoing manner, as well as receive summative feedback thereby allowing for deep learning. The assessments also promote the use of assessment tasks which not only assesses the capacity to recall information but also assesses the students' capacity to investigate, apply concepts to new problems, produce, and demonstrate - one of the 16 indicators of effective assessment in higher education as proposed by James et al (2002). The repeated learning cycle accompanied with constructive formative and summative feedbacks and discussion with the teaching staff is in line with principle 7 of the nine principles guiding teaching and learning at the University of Melbourne which is 'Learning cycles of experimentation, feedback and assessment'. The assessment tasks and the repeated cycle of activities require input from individual students and presumably should increase the likelihood of students being motivated to learn on an ongoing basis. The act of putting thoughts together individually and in group and developing a solution could also allow students to clarify their ideas. The progressive and repeated assessment throughout the semester allows student to know how they are going in the subject and it also helps teaching staff to identify students at risk thereby helping the student seek help early. This is in line with principle 5 of the nine principles guiding teaching and learning at the University of Melbourne which states: "explicit concern and support for individual development' (James 2007: pp 10). The small group discussions and group assignments enhance students' understanding and encourage students' participation; and help the student take control of the learning process. According to one study (Abercrombie 1969 cited in Biggs and Tang 2007) solving real life problems in groups can increase student's professional competence. The mix of assessment (individual and group) encourages individual participation, and students' interaction/collaboration and peer learning. It has been observed that activities that bring students together for the purpose of study can enhance students learning (James, 2007). Also the assessment tasks are organized in incremental and progressively manner through the semester so that student will receive feedback that they can take on board when doing the next task. This should also increase students learning and so an increment in the quality of students' work and students' submission over time during the semester. An upward trend in the students' mark is also expected since students are learning by doing and the more assignment they do they better they understand and better they perform when compare to a previous assignment. Small group discussion and interaction during lectures and tutorials as well as peer teaching in tutorials also encourages inclusiveness. This should help international students who may be reluctant to contribute. The face-to-face interaction with the teaching staff and by email (both individually and as a group) enables students to seek advice, support and guidance on any difficulties encountered. Again this is in line with Principle 5 of the nine principles guiding teaching and learning at the University of Melbourne states: "explicit concern and support for individual development' (James 2007: pp 10). It encourages inclusiveness in a culturally diverse student cohort.

In 2011, students' feedback from the Students' Experience Survey (SES) clearly reflect the success of the using constructive alignment and interactive teaching. Students scored subject on a scale of 5, 4.6 on question four (…well taught); 4.3 on question one (…intellectually stimulating); 4.5 on question six (..found assessment tasks useful in guiding my study); 4.3 on question seven (...received valuable feedback on my progress); 4.4 on question eight (..learnt new ideas, approaches and or skills); 4.6 on question nine (...learn to apply knowledge to practice). The students also realize that what was learnt would be useful when they graduate. The subject was rated 4.8 on question thirteen of the SES (..the subject has equipped me with the skills that would assist my future professional development). The SES comments also support the success of the use of constructive alignment and useful ongoing learning support given to students. One student said "The subject was well planned and organised. Expectations were clear." Another one said: 'the teaching staff made what is generally dry subject matter to somewhat interesting. [this] actually made me consider a future career as a quantity surveyor. The assignments were a lot of work, but very helpful in fostering an understanding of the subject matter and allowed us develop new skills'. In their own words some students also believed that: "the assignment were very helpful in putting the lectures into perspective, and allowed more understanding". One student said: 'Liked that [the teaching staff] gave examples of good assignments'. Turning to what student feel about having to work in groups and tutorials, one student opined: "The group work was good, as it provided us with the time to learn how to measure more things, while not increasing our work load. Also, I thought the tutorials where we got to work on the assignment was really helpful, as questions asked in the tutorial, I would probably not have asked if there was no tutor available at that given moment."

8. Conclusion

Students need to develop practical skills and experiential knowledge as well as understand concepts so that they are able to immediately put the knowledge developed to work immediately after graduation in a professional discipline. The conventional approach to teaching and learning typically focus on what teachers teach in class or what will be taught rather than what students will learn. This approach usually ends up making teaching and learning teacher-centered rather than student-centered. It typically makes many students become passive learners and passive recipient of information presented by the teacher. The approach fails to recognize that students learn in different ways and so there is need for subject curriculum to motivate and help all students' to actively participate and get involved in their own learning and achieve specific pre-defined outcome from that learning process. To facilitate active student learning, help student develop knowledge of concept as well as application of concept in practice, curriculum design need to start by defining clearly and explicitly the intended learning outcome linked to competence required of student when they graduate. This should then be followed by designing teaching and learning activities that can help student best achieve those outcomes. A pedagogy based on the principles of constructive alignment coupled with interactive teaching can help to achieve this outcome by promoting deep learning through an ongoing learning cycle of experimentation, assessments and feedback. The assessment tasks should help judge if and how students' performances meet the learning outcomes in an ongoing basis. In professional discipline, rather than using assessments to discriminate low and high performers, assessments should focus on measuring if a student's learning has increased and has met the intended learning outcome as a result of the learning process.

The repeated and progressive learning activities is potent to deliver the intended goal – enabling student to understand principles, gain technical skill and experiential knowledge so that they are able to put concepts to work in real world, it may be counterproductive if it substantially increased students workload so that they are under enormous pressure. The effect is that that they may take a surface approach to their learning. There is tendency that the approach can lead to excessive assessment which must be avoided (as recommended by James et al., 2002). At the moment there is no concern that this is the case. Another concern related to workload is the distribution of marks among the assessment tasks. At the moment, the learning activities (4 tasks) constitute 40% of the total mark. In addition, students need to do a 3 hour exam to obtain the remaining 60 marks. These concerns are not expected to invalidate the method. It would be useful to monitor and investigate empirically the impact of the teaching approach on students learning using a longitudinal study. Should workload be an issue, there would be a need to fine-tune and modify the method. If findings suggests that workload is an issue for students, there may be need to rethink the distribution of the mark; perhaps by increasing the total mark obtainable for the assignment. If the ongoing assignments achieve the learning outcome and they are adequate and are well assessed, having a 60% end of the semester exam may not be necessary. Perhaps encouraging students to devote more time and effort to the assignments by allocating more marks to them may be more productive.

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An updated review of intensive design weeks for architectural technology programmes

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Abstract

Architectural Technologists are uniquely positioned to deliver wholesome technological building solutions; solutions that address sustainability, economics, social and psychological requirements. The structure of the Architectural technology courses differs from institution to institution in the UK; however, at the core is the objective to prepare the students for the real challenge of the multi-disciplinary nature of the profession while in practice. The teaching, learning and assessment strategies employed in delivering the curricula are crucial for achieving this objective. In order to facilitate or improve the teaching and learning experience in Architectural Technology programmes, it is imperative to design and structure teaching in a manner that reflects what the students will experience after graduation. To achieve this real and active learning process, a hands-on approach to teaching (and learning) is required.

The design block week is an intensive learning experience which aims to immerse students in a focussed, project-based environment where through collaborative working they are encouraged to explore unique solutions to design and technological problems. It has long been recognised that intensive block weeks offer advantages to enhance core competency in students as well as fine-tune soft skills. To further contribute to the pedagogical debate, this paper revisits the intensive design week as a tool for delivering experiential learning to students. It re-evaluates the design and delivery of an intensive design week programme, now in its third year. Using quantitative data derived from student feedback, it discusses whether this approach continues to be effective and makes recommendations.

Keywords: Architectural Technology, Alternative modes of teaching, Design Education, Intensive Teaching Block

1. Introduction

The design block week is an intensive learning experience which aims to immerse students in a focussed, project-based environment where through collaborative working they are encouraged to explore unique solutions to design and technological problems. Advantages of block teaching include flexible mode of teaching, increased student motivation and interaction, improved discipline, time savings and increased academic performance (Davis, 2006; Jonas et al., 2004; Grant, 2001). The nature of intensive block weeks can also help to improve the students' soft skills e.g. time, project and people management.

When the intensive design week was first introduced to the AT programme in 2009, the decision was made to carry out a 'before and after' study to ensure that this approach to teaching and learning contributes value to the programme and is appropriate for design disciplines. Findings from the first study are detailed in Adeyeye *et al*. (2011). The research question was whether intensive teaching continues to positively contribute to architectural technology students' learning experience without compromising the learning objectives defined in the module descriptor. Also whether:

- By concentrating on a smaller subject area/content e.g. architectural structures, students are less distracted and are therefore able to focus and learn more through research, discussion and application.
- By restricting the study period to a five day work week, it is possible to simulate an environment where students can apply what they have learnt.

This paper presents an updated review of intensive design weeks in AT courses. The aim of this study was to evaluate the continued effectiveness of the intensive design teaching and learning programme three years since inception. The design week is now in its third year and this study was aimed at assessing if the programme is still delivering the desired objectives: to enable students to acquire and apply specific knowledge relevant to their core modules in an environment that simulates AT professional practice. It is important to state that this study is not designed to directly assess improvement in academic performance but to assess whether the learning outcome – to improve knowledge and competency in architectural structures, was achieved.

2. Experiential learning

Literature presents an ongoing debate about whether knowledge is gained by abstraction or by concrete experience. Piaget (1972:53) argues that psychologists and behaviourists "...attribute all knowledge to learning as a function of experience", whilst epistemologists "...see in logico-mathematical operations only a simple language of tautologies for translating the data of experience". While Freire (1985:115) suggests that abstract knowledge is merely another's experiential learning, arguing that if knowledge is gained by concrete experience, perhaps it is also possible to derive learning from others' experiences. People learn by fitting new understanding and knowledge into, with extending and supplanting, old understanding and knowledge (Fry et al. 1999). This premise is applied here in anticipation that by building on existing knowledge and experiences rather than independently introducing new concepts, students will develop a deeper understanding of architectural design and technological detailing. Principally, applying experiential methods in design disciplines assist the teacher to facilitate learning by encouraging students to reflect upon those experiences and draw in the established theories developed by others. In this environment, students can also obtain knowledge through a shared experience which they could then link to their individual and unique experiences. Exponents of experiential approaches to teaching also suggest that by integrating 'doing' into the learning environment, it is possible to facilitate deep and active 'learning'.

Globally, rapid transformation and changes are taking place and the higher educational institutions are not immune to this trend. It is therefore not surprising that teaching methods have also been changing. As a part of the process of adapting to changing student demands, universities have had to consider new ways of delivering course content. A practical example of this is the move from traditional to ‘intensive’ modes of teaching (Davies 2006) by some well established institutions. Davies defined *Block modes as very large chunks* of teaching time, for example whole day sessions, offered in week-long mode, two or three-week long mode and weekend mode. These forms of teaching are in contrast to ‘traditional’ teaching formats of hour-long or 2 hour-long lectures during semester-length courses (Jonas *et al.* 2004). Intensive teaching was initially developed to allow institutions to deliver content in an accelerated schedule because of time constraints and has its roots in a variety of educational environments (Ho and Polansky 2007).

Other research findings have suggested that learning outcomes are equivalent or better than the traditional mode of delivery. Some reasons given for this are better student interaction and commitment, as well as increased academic performance (Grant 2001; Seamon 2004). This supports the claim that more students now appear to want or even prefer more interactive classes that engage student learning (Ramsden 2003). This is amidst suggestions that students’ participation in lectures and tutorials are declining. Although according to Davies (2006), it is also unclear whether and to what extent the method of delivery of course material, i.e., the instructional approach, has a major bearing on learning outcomes. The generic objective of the design week discussed in this paper was to communicate theory reinforced by practical applications. The programme was designed to reinforce theoretical knowledge of structural design and detailing through the process of ‘making’. This concept rests on the notion of continuous building and amending of previous structures, or schemata, as new experience, actions and knowledge are assimilated and accommodated.

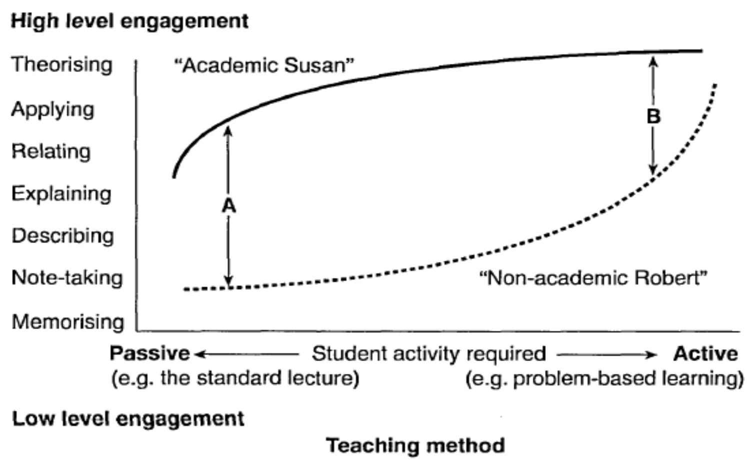

Figure 1 - Student orientation, teaching method, and level of engagement (Biggs 1999).

Biggs (1999) recommended this approach in his discussion on the correlation between student learning and teaching method (Figure 1). He suggested that problem-based learning as an active method *requires* Non-Academic Robert to question, to speculate, to generate solutions, to use the higher order cognitive activities that Academic Susan uses spontaneously. A typical cohort is likely to comprise students across the spectrum in differing percentages. The challenge is to ensure that majority of the students achieve higher order learning where they are able to apply what they've learnt as well as translate this to create new knowledge when required.

Using teaching strategies which realise both low and high level objectives – cognitive, affective and psychomotor (Reece and Walker 2003) help to ensure that learning objectives are attained; albeit from a teaching point of view. It was therefore equally important to create an environment where it is possible to communicate the noticeable progress to each individual student in order to motivate and encourage them to make consistent progress. The intensive design week facilitates this because it forces both teacher and student to 'communicate' and 'interact' in order to achieve a predefined goal. Feedback then becomes an active, continuous process rather than a one-off at the end of the exercise. Ramsden considered prompt and early feedback highly important. He stated that a lecturer or course applying sophisticated understanding of teaching is aware that every evaluation of a student should be valuable to the student as well as the lecturer (Ramsden 2003). This makes assessment and feedback an essential part of experiential learning (Ramsden 2003, Entwistle et al. 1989, Adeyeye 2009). Assessment if properly designed and implemented is beneficial for telling us whether or not the learning was successful, to convey to students what we want them to learn (Biggs 1999a). Combining assessment with good feedback, if well implemented, becomes a reiterative process of ongoing dialogue during experiential learning. And experiential learning closes the loop when the right level of information is provided in an environment that allows for freedom of independent and collective, yet personal thinking. Especially as it gives students a reasonable level of control over their own learning – as an active not passive experience, for which they take pride in the outcome (Adeyeye 2009).

3. Research Methodology

This paper is the second phase of a reiterative action research approach which consists of the following 4 stages, with the last 3 stages repeated annually:

- Examine existing materials on block week teaching pedagogy for design and non-design related courses.
- Design and deliver a one-week intensive design programme on architectural structures for second year undergraduate Architectural Technology students.
- Observe and evaluate the effectiveness of the design block study programme to promote learning, reflection and retention.
- Analyse quantitative (and/or qualitative) data, make recommendations and conclude from findings.

This reiterative approach was proposed in response to the need for more research into the efficacy of block study weeks in design subjects, and to answer the question of the subjective nature and reliability of findings of studies that were conducted. The initial research after the first design week utilised a mixed method approach which was useful for addressing problems that stem from studies relying upon a single theory, single method, single set of data and single investigator (Burgess, 1984, p.144) and helped to ensure that the results are not method specific and help their generalisation within the same course and across other built environment courses. This approach is continued in the reiterative study phases with students required to complete post design-week questionnaires as well as reflective log books. This paper will discuss the findings of the third post-design week questionnaire, comparing findings with the data obtained from the first study in order to determine if the programme continues to be effective in achieving the learning objectives.

To provide further context, the intensive design week (henceforth referred to as design week) programme is delivered to second year AT students only. The first year had 28 students participating and in the current year, 22 students participated. The design week programme takes place in week 7 of the first semester in the academic year and the post-design week survey was conducted between weeks 5 to 7 of the second semester. The duration of the design week is one week; Monday to Friday and strictly from 9am to 5pm each day. At the end of the week, students present their work to a panel of academic and industry assessors. Prior to the intensive design week, a project brief was designed and issued to each student. To facilitate comparison, the same brief issued at the first design week was repeated this year. The client's brief required that students, in maximum teams of four, designed and built a temporary exhibition pavilion on a specified site within the University of Brighton's Moulsecoomb campus. This site, in addition to its unique challenges, was chosen for ease of access and familiarity to the students. Although students were required to conduct a site and space analysis in order to facilitate their design development process, the ability to do this is not one of the intended learning outcomes. The main learning outcome was to further develop student's skills in architectural structures through exploring material and buildability issues.

The project accounted for 20% of the total allocated mark for the (20Credit) module, and was split 60%/40% between the group and individual components. The group work was a 1:100 scale physical model of the pavilion, detailing model(s) of key interfaces as well as a poster. In addition, each individual student was required to submit a portfolio to include their contribution to the group work as well as a reflective log book. Attendance for the five days was compulsory. The group work had to be ready to be presented by 3pm on the Friday and individual portfolios were to be submitted by 10am the following Monday. The limitations of this study were: the limited sample of students – one cohort of 28 students in the first research year, and another cohort of 22 in this research year. Also, even in this third evaluation cycle, it is still difficult to determine a quantitative measure of retention of learning and further research will aim to propose a research framework and methodology for this.

4. Comparative findings

For the first survey, questionnaires were deployed before and after the design week and students' response were voluntary. With the pre-design week questionnaire a 75% response rate was achieved. In the post-design week survey a 67% response rate was achieved. Three years on, a similar questionnaire was deployed again but this time, post-design week. Participation was also voluntary and 64% of the 2nd year AT cohort participated in the survey. The questionnaire asked students to rate their competence in key skills and competencies such as spatial design and structural design skills as well as soft skills such as communication skills, presentation skills, coordination skills and managerial skills. This paper focuses on findings from the former.

4.1 Survey findings on spatial and structural design

This year’s survey commenced with general questions to gauge students teaching, learning, assessment, and feedback preferences. After the general questions, students were asked to rank a range of teaching techniques/methods in order of preference. The results contradict initial findings although methods that promote experiential learning still ranked highest in both studies (figures in brackets indicate data from the first design week study) e.g. work-based learning at 83% (64%), field trips was chosen by 50% (79%), studio-oriented teaching 67% (87%) , and intensive design weeks 50% (73%). It is noted that the figures are lower this year compared to three years before. There was however consensus on formal/traditional 33% (39%). Also this year, student-led seminar 0% (43%), peer and study groups 0% (67%) were the least favoured by students.

Similarly, the students were asked to rank assessment methods in order of preference. Again, time-restricted projects with clearly defined outputs were ranked highest by 100% (50%) by the responding students and the design week is centred on this form of assessment. Also results on problem-based learning e.g. design projects linked with real sites and issues was consistent and ranked highly by 100% (80%) of students. 67% (57%) did not like examinations. Following on from this, 69% (79%) of the students preferred immediate feedback e.g. during design ‘crits’ or in-class. This they considered more beneficial to having to wait to find out how they’ve performed in their projects, coursework or examination.

As shown in the previous section, the questionnaires comprised questions which attempted to measure knowledge and skills as perceived by students before and after the design week. Knowledge and competence in architectural structures was the primary learning objective of the design week. For the purpose of analysis, improvement in spatial design skills was also assessed as the two factors are not independent of each other. Therefore, questions were designed to particularly measure if this learning outcome was achieved. Again, the percentages in brackets represent data from the first design week. Before the design week, 60% (29%) of students rated their *competency* in spatial design as good, while 20% (53%) rated their competency as average. None in both instances considered that their competency of excellent standard (Figure 2a).

After the first design week (Figure 2b), on one hand, the *knowledge* in spatial design improved with 20% (6%) of students now considering their skills excellent. However, the ‘good’ to ‘average’ figures remained the same at 60% (13%) and 30% (75%). Also, it was noticeable that the data from the first design week showed that those students felt their spatial design skills was worse after the design week. The reasons for this was further investigated and reported in Adeyeye *et al*. (2011). This year’s figures are not much improved, primarily because there were little spatial design requirements in the client’s brief and majority of the students concentrated their efforts on the structural design, detailing and buildability.

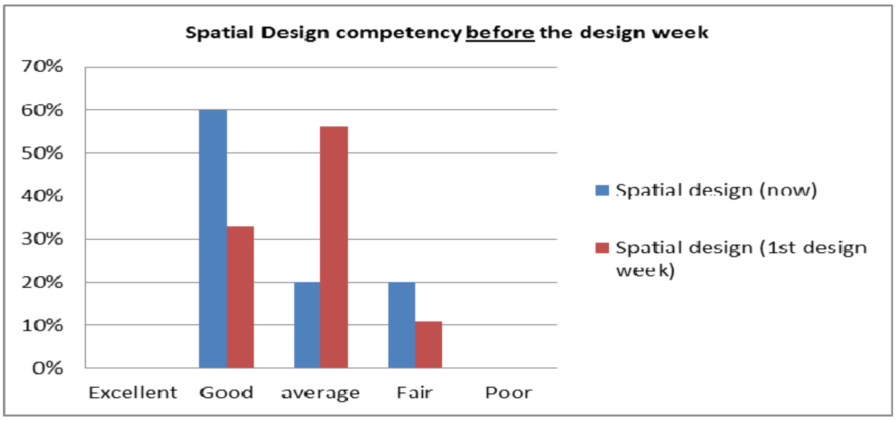

Figure 2a: Self assessed spatial competency before the design week

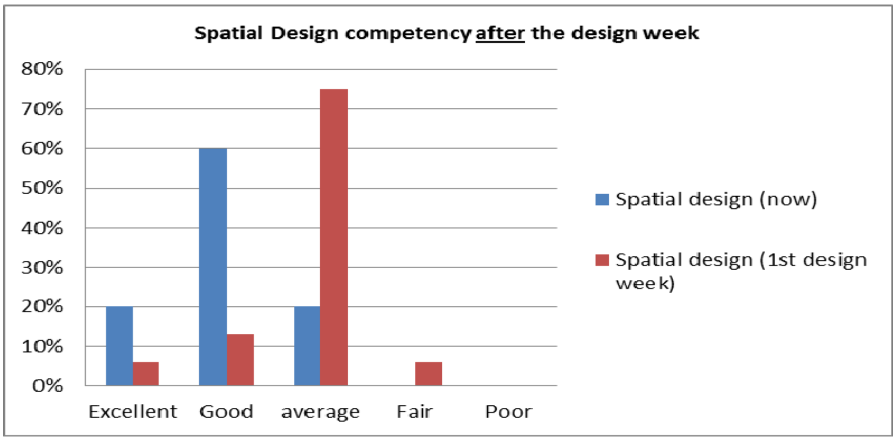

Figure 2 b: Self assessed spatial competency after the design week

Similarly to spatial design, questions on structures were asked in the pre- and post-design week surveys. Before the design week, 20% (33%) of students rated their *competency* in architectural structures higher than average, while 80% (67%) rated their competency as average. None in both instances considered that their competency of excellent standard. After the design week, all the students (100%) agreed that their *knowledge and competency* of architectural structures increased significantly after the design week. Comparatively, only 88% made the same assertion three years ago at the first design week programme.

Although the design week appears to be successful in achieving the primary teaching objective which was architectural structures, it was important to gauge the extent of this success and how much of the positive change can be attributed to the design week. The response varied considerably. Figure 3 shows the comparative data between the first design week three years ago and the most recent one. Findings show that students attributed their significant successes in learning to the design week three years ago. Dissimilar results were found this time when students were asked if their increased competency can be attributed to the design week. In the current study, majority of the students indicated a neutral benefit for the design week. This is however understandable. The purpose of the first design week was to augment the curriculum in architectural structures. Since the first design week, the teaching curriculum had been revised and the current AT students had received lectures in architectural structures which culminated in a group-based structures project prior to the design week.

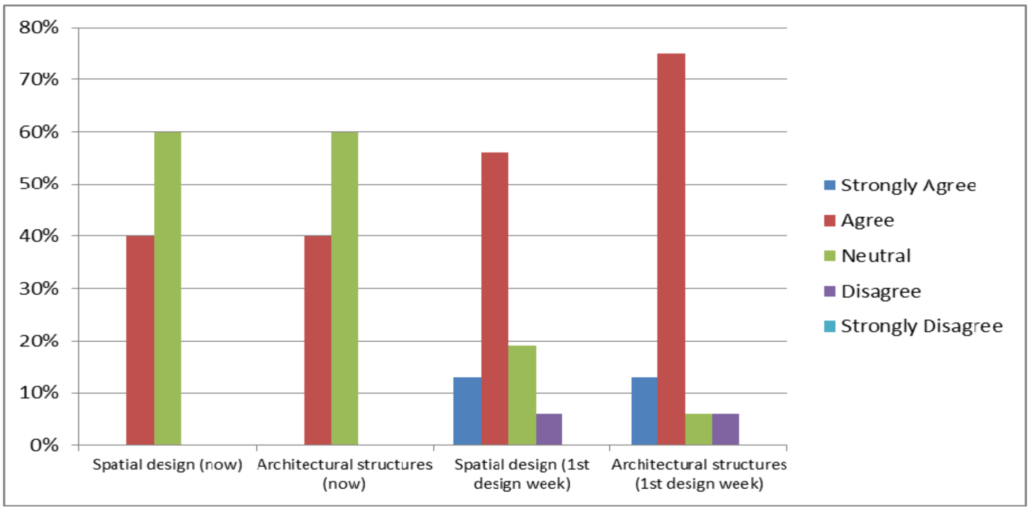

Figure 3 Learning attributable to the design week

The finding presented in the previous paragraph reflected the opportunity for students to further apply their knowledge and competency in an intensive environment whilst gaining other non-tangible skills or benefits. This is quite fundamental as the traditional teaching approach sometimes mean that new concepts are introduced each week, leaving the students little time to digest learning from the previous weeks. This is demonstrated in the comments below:

> *"...liked the design week because it had clear objectives, achievable targets within structured timetable"*
>
> *"...liked the design week for the fast learning environment, group learning through testing and discussion"*
>
> *"...really good to be under strict deadline and make daily progress towards this"*
>
> *"...liked the teamwork and the efforts everyone put into the projects"*
>
> *"...designing and practical learning. Enjoyed sketching, then putting these design methods into practise"*
>
> *"...the ongoing support/ guidance received throughout the week"*
>
> *"...stretched my limit of patience, but enabled a more hard working persona that i hadn't previously seen in myself"*
>
> *"...good to have people from industry come in for the end of week 'crit'. Makes the whole project feel more live-like/pitching to clients"*

Interestingly, when asked what they did not like about the design week, majority of the students primarily said they would have preferred to choose their own team members. Others include the fact that the studio was not accessible for 24 hours, in essence wanting to work longer than the time allowed, one said he/she did not like the pressure caused by restricting the time within 9am-5am.

Other students mentioned their performance during the final presentation, reflecting that they did not do so well but also recognising the need to improve. The design week was therefore beneficial for promoting self-reflection in students where they felt comfortable to assess their strengths and improve their weaknesses.

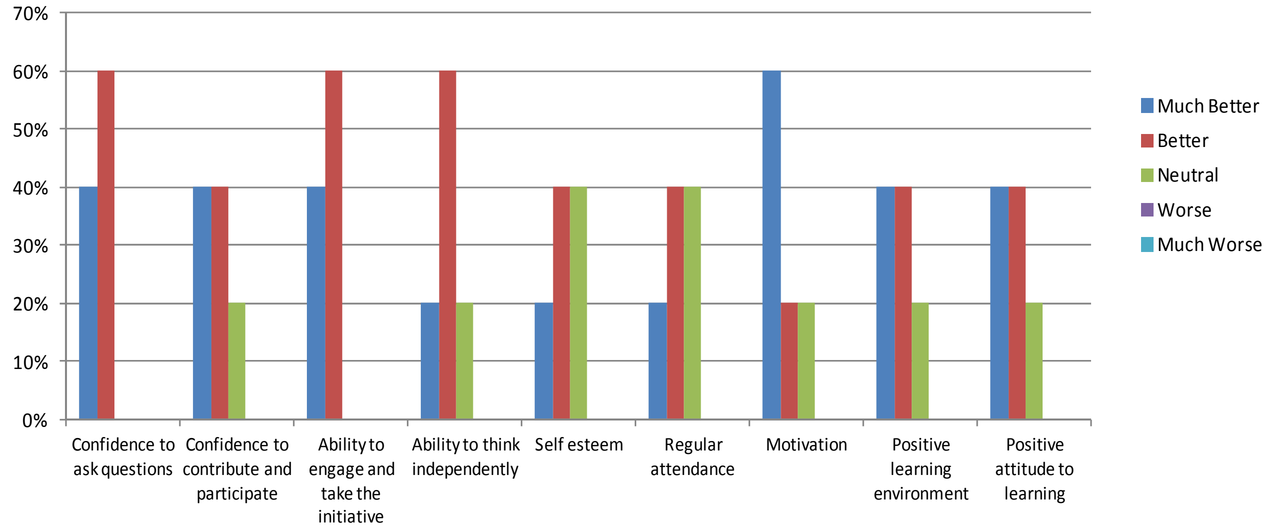

Figure 4a Current study: Other perceived benefits from the design week

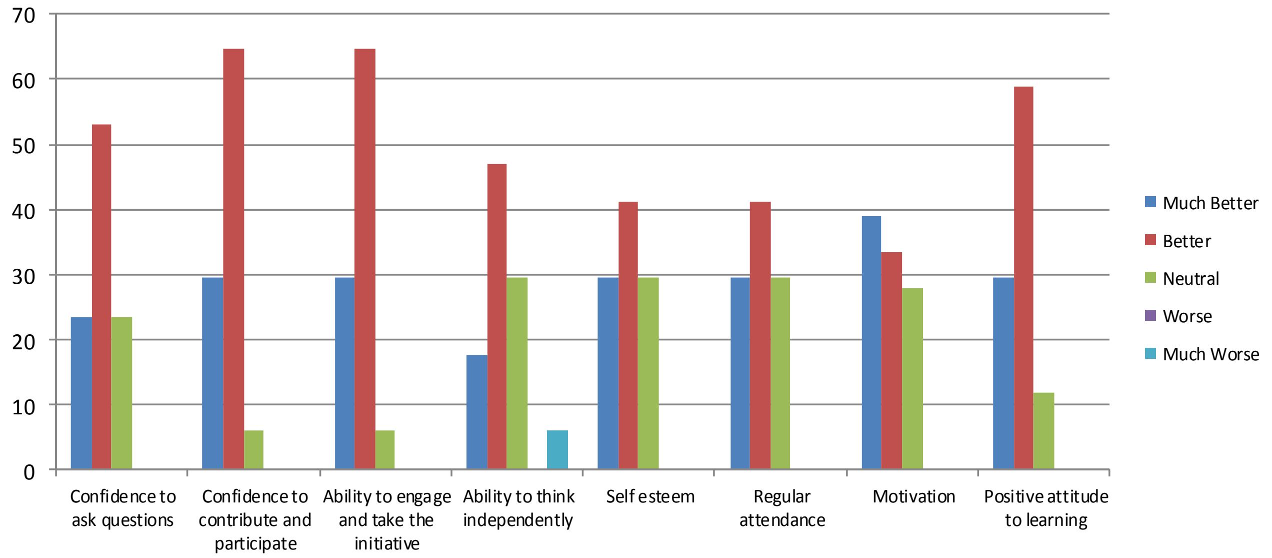

Figure 4b Previous study: Other perceived benefits from the design week

Lastly, students that participated in the third design week gave the following feedback about what they indirectly gained from the design week. Figure 4a shows that 60% of responding students stated that their motivation significantly improved after the design week. 20% said it was better. The same percentage also stated that their confidence to ask questions, participate, engage and take the initiative in their learning was also better than before the design week. No student said they were worse off although 40% of students remained neutral about self-esteem and improving their attendance. Comparatively, in the previous study (Figure 4b), 39% of responding students stated that their motivation was much better after the design week, than before the design week. 33% said it was better. 24% said their confidence to ask questions was much better, against 53% who said it was better. Similarly, 29% and 65% said their confident to participate and contribute in class was much better and better respectively. Similar trends was repeated for each of the variables except for a significant increase in positive attitude to learning and one of the responding students stating that their ability to think independently was much worse after the design week.

5. Discussion

This research aimed to assess if the intensive design week programme in the AT course continues to be effective after the third year. Findings confirmed that the students continue to respond positively to, and benefit from the challenges of the design week. Also, findings confirm that the design week continues to help students to achieve the learning outcomes, which was primarily on architectural structures. However, this year's finding highlights that the design week was more beneficial to reinforcing experiential learning, rather than creating new knowledge. Thus confirming that the design week approach is more beneficial for reinforcing and translating theoretical knowledge (e.g. gained in lectures and studios) into practise (e.g. physical modelling), thereby helping students to understand the cause and effects of their designs and to resolve practical design issues in a practical way. The design week was not effective in teaching spatial design in both studies and it can be concluded that intensive block teaching is not a suitable method for this. The studio-based learning approach was much preferred method for this subject.

At the beginning of the paper, it was argued that feedback and assessment are integral parts of experiential learning. The design week environment enables the use of both Formative (assessing for learning) and Summative (assessment of learning) assessment methods in a seamless manner. This is perhaps the most useful outcome of the design week in the three years of running. Integrating many opportunities for feedback and assessment into the week's programme considerably improved the perception and attitude to the summative assessment at the end of the week. Majority of the student's feedback did not consider the Summative 'crit' in terms of what their grade was but in terms of the value of the 'on-the-spot', direct feedback received, the opportunity to demonstrate their presentation and communication skills and the opportunity to interact with and receive feedback from peers, academics and industry practitioners. Another consistent finding was the benefit of the design week in improving non-tangible, yet valuable soft skills in students through engaging in tangible, measurable projects. After spending an entire week in the same space with staff and other students, the subsequent studio sessions were much improved. Students become more confident to ask questions, engage, participate and support one another. They had a more realistic perception of their strengths and majority commit to improving their capabilities. Motivation and engagement is usually better than before and the staff-student relationship significantly improves as well.

6. Conclusion

This research confirmed findings from previous studies which stated that intensive block teaching produced learning outcomes which exceeded what would have been achieved through the traditional mode of teaching and assessment. However, it is more effective for translating theoretical (passive) knowledge to (active) experiential learning. In addition, the design week is highly beneficial for improving student engagement and interaction. Evidence also suggests medium term retention of technical skills to support the soft skills; time and project management and people skills gained. In view of these findings, the intensive design teaching programme will be significantly revised and scaled up to deliver a cycle of teaching, learning, feedback and assessment which ensures that in addition to delivering the knowledge aspects of the curriculum, students are afforded several opportunities to translate these into long term learning through practical, experiential exercises.

To conclude, the aim of this research was to investigate the continued efficacy of the design week as a means of improving knowledge and competency as well as participation, engagement and the learning experience of architectural technology students. At the end of this study, the efficacy of the design week was confirmed, however, the learning outcomes delivers a different kind of value in ensuring that passive teaching is translated to active learning by students. Questions for further study include; the extent to which the intensive programme results in long term retention of learning and if the approach to teaching and learning is viable for other subjects within the Architectural Technology curricula. The transferability of these research findings to other disciplines or even interdisciplinary subjects is also worthy of exploration. Lastly, future studies can aim to develop a framework for designing, implementing and evaluating intensive design weeks in vocational subjects such as architectural technology.

7. Acknowledgements

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Toward an Understanding of Research Fundamentals to Support Graduate Education in the Built Environment

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Abstract

Most research universities require some combination of standardized classroom teaching and independent research as part of a post-graduate level plan of study. Increasingly construction management, construction technology, architecture, and related programmes that award degrees related to the built environment (BE) are awarding post-graduate degrees. Frequently these degrees, unlike traditional engineering degrees which test theory from a quantitative or positivist position, relate to issues that are more difficult to measure using strictly quantifiable metrics. Because the managerial issues faced by these graduates deal with human interaction and behaviour, research in the BE often resembles social science research to a greater degree than traditional scientific research.

As post-graduate programmes in the BE expand, there is an increasing need for student support in the research fundamentals that are required to complete valid research on construction and design issues. Small programmes can rely on the individual mentorship of students, but as student populations grow a more formalized approach is needed to support varying research methodologies employed by post-graduate students as they complete their thesis or dissertation obligations.

This paper is an examination of the research fundamentals approach to post-graduate education being used by construction related research programmes in a sample of universities in the US and the UK/Ireland. Emphasis was placed on understanding the current educational support for the understanding of research fundamentals critical to research in the built environment. The research utilized both a literature review and a survey instrument. Specific areas of research examination included information detailing the educational unit(s) within the university with responsibility for teaching research fundamentals, research fundamentals courses available, the research philosophy or approach emphasized, and the text or other literature support utilized to advance valid research design by post-graduate students.

Keywords: Graduate Education, Research, Curriculum Development, Validity, Methodology

1. Introduction

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

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

Historically construction industry hiring practices have not placed as high a priority on post-graduate level education in both the US and Europe. Some CM educators have advocated the need for post-graduate education programmes that are fully aligned with the construction industry. Rounds noted in 1997 that post-graduate level CM programs would advance the body of knowledge of the industry, provide professional construction educators with industry specific knowledge, and develop graduates with advanced skills appropriate for executive level careers in construction. In addition, the need for professional construction educators was addressed in a 2005 task force report to the Board of Directors of the ASC which examined the need for and the appropriate format of a PhD degree in Construction Management.

In the early years of the 21st century, the increasing demand from the construction industry along with the growing demand for construction educators stated earlier has encouraged the growth of post-graduate education specific to the BE. In 2007 the Associated General Contractors (AGC) of America, a US trade association comprised of more than 33,000 firms, expressed the organization’s support for advancement of post-graduate CM programs. They stated “The need for senior executives to secure a masters (in construction management) is apparent from two perspectives. First, they will benefit from learning newly evolved construction techniques and management methods. Second, their experience is needed on campus as instructors” (Behling, Orczyk & Jenkins, 2007).

Although post-graduate enrolments and job opportunities have at times been inconsistent, enrolment growth has been experienced by some universities. Table 1 shows the results of a telephone survey of some of the largest university construction management programs in the US conducted in 2010 by one of the authors. These results revealed substantial enrolments in Master of Science programmes. Table 2 shows the results of a telephone survey of a select number of university level institutions offering postgraduate programmes in the BE. Within the BE domain in the UK and Ireland a greater number of post-graduate programmes have emerged in the last decade, including masters by research to BE professional doctorates. These have added greatly to the increase in post-graduate research.

Table 1: Enrolment for the 2009 – 2010 Academic Year

Institution & Department	*Type*	*MS*
Arizona State University, Del E. Webb School of Construction	*Full Time*	*48*
Auburn University, McWhorter School of Building Science	*Full Time*	*31*
Colorado State University, Department of Construction Management	*Full Time*	*40*
Purdue University, Building Construction Management	*Full Time*	*7*
Texas A&M University, The Department of Construction Science	*Full Time*	*90*
University of Florida, M.E. Rinker, Sr. School of Building Construction	*Full Time*	*110*
Virginia Tech, Department of Building Construction	*Full Time*	*20*

1.1 Research as a Component of Traditional Post-Graduate Programmes

Gumport (1993a) has traced the role of research in post-graduate education during the last century as part of a book titled *The Research Foundations of Graduate Education: Germany, Britain, France, United States, Japan*. Beginning in the late 1800s, research and post-graduate education became closely linked at major universities primarily through the growth in the disciplines of science and engineering. The common practice of post-graduate student education in the US at that time consisted of a period of class-based study followed by research. Post-graduate education during this time period evolved to become a mentor based learning environment where students worked alongside professors on research projects. The benefit of this mentor-based process was that students would transition from consumers of research to producers of research. This process was accelerated in the post-World War II period where the economic expansion and cold war competition of the time period encouraged significant financial support for research. By the 1970s top tier universities had interwoven organized research and post-graduate education and lower tiered institutions strove to emulate this practice.

As US Federal research funds began to diminish in the 1970s and 1980s, reduced financial support for post-graduate students impacted the student-faculty mentor relationship by limiting the degree to which faculty could work directly with students in the research setting. The relationship began to evolve into one where the students worked more independently, often on research that the faculty mentor was not involved with. This reduced integration of post-graduate education and organized research activity occurred at the same time that professional graduate education began to emerge. Professional post-graduate education, which was intended to provide a more market-driven practitioner rather than a researcher, reduced the need for graduate research experiences (Gumport, 1993b).

Many of the traditionally research oriented disciplines in engineering and the applied sciences have an option for a non-thesis MS degree. A common alternative to a course-only MS degree as a non-thesis option is provided through the use of a directed project rather than a thesis. The directed project is less formal than a thesis with the objective to engage the student in an industry based study culminating in a report. The topic is generally more practical than a thesis and is expected to be completed in one semester (Hartman, Sarapin, Bertoline & Sarapin, 2009). Some educators have questioned the validity of course-only graduate education even in applied engineering technology post-graduate programs. Grubbs and Kozak (2000) cite the fact that without a thesis, students do not support growth of the body of knowledge in a discipline or even focus on applied solutions to problems in the workplace. They place into question what value is added in a non-thesis graduate degree beyond what is learned as an undergraduate.

1.2 Research Problem and Significance

Although some universities may offer non-thesis post-graduate options, research will continue to be a significant component of the post-graduate education provided by many construction management programmes. Some programmes consider research to be the most effective approach to the promotion of self-education or life-long-learning. Others see the need to maintain a research focus to support those who will become future educators of the BE. In some cases programmes may be given little choice within the university structure in which they operate. As post-graduate programmes grow many will face challenges in supporting the educational needs of their students. The potential for these challenges become more apparent as construction researchers expand the diversity of research philosophies and research methodologies considered appropriate for research in the BE.

Those BE programmes that depend on the regular supervision of post-graduate students by mentors within the programme are limited by the capacity and number of mentors available. Programmes that look to the college or university in which they operated to provide courses in research fundamentals are limited by the range of research methodologies provided at that level. Ultimately the question must be asked “what are the most appropriate ways to prepare post-graduate students for their research activities”? This paper attempts to provide the first step in that quest by exploring what post-graduate programmes in the BE are currently providing as research fundamentals resources for their students.

2. Evolving Construction Research Philosophy

Quantitative or positivist views of construction research dominated early construction research published in academic literature. Possible explanations for this include the fact that many construction educators came from backgrounds in engineering where quantitative research is utilized both because of its ability to demonstrate scientific rigor and validity as well as the relative ease of relating engineering theories to mathematical analysis. During the last few decades an evolution in thinking about research philosophy in construction research has come about. In 1997 Seymour, Crook and Rooke called for a debate on the role of theory in construction management research. Seymour et al. encouraged a dialogue about the need for a broader view of alternate research paradigms. They contended that the management components of construction require a more interpretive view of research that necessitated a reconsideration of what defined theory, rigour, and objectivity in construction research. Later that year Runeson responded to the call for debate by stating that positivist research is the best insurance against bad research. Although Runeson acknowledged that interpretive research has a place in normative research, he asserted that it should not be taken as science. His arguments placed a clear demarcation between the value of qualitative and quantitative approaches.

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

2.1 Research Methodologies Appropriate for Construction Research

When a theory or hypothesis fits available data or realities of data acquisition, experimental approaches to construction research is preferable because of its ability to produce generalizable results. Frequently these experimental approaches require the researcher to separate naturally occurring phenomena into small components that facilitate data collection. Bernold and Lee (2010) describe five methods of experimental or quasi-experimental design commonly used for construction research. These five methods; pilot testing of devices and methods, passive observation, controlled experiments, randomized experiments, and four group experiments may be favoured when measurement of well defined variables can be obtained. Unfortunately, conditions that allow such measurable evidence to be collected are often confounded by conditions beyond the researcher’s control.

To overcome the challenges of experimental design, alternative philosophies and methodologies have been adapted from research more common to social science. A complete description of the range of research methods at the construction researcher’s disposal is beyond the scope of this paper. However, a recent issue of the *Journal of Construction Engineering and Management* contains several articles describing both experimental and alternative approaches to construction research that can serve as useful reference material. Table 2 lists the range of methodologies and approaches described. While this list is by no means exhaustive it does show the breadth of research tools with which post-graduate students should be exposed in their education.

Table 2: Research Methods in Journal of Construction Engineering and Management, January 2010

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

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

3. Methodology

The exploratory study described in this paper sought to identify what post-graduate programmes in the BE are currently providing as formal research fundamentals educational resources. The scope of the inquiry was to examine course-based education in research fundamentals based on the concept that students require a formal introduction to a diversity of research philosophies and methodologies appropriate for use in construction research. Although possible through one-on-one interaction with a research mentor, growth in graduate enrolments make sole reliance on supervisory guidance for research fundamentals education increasingly difficult. The primary components of the inquiry were intended to disclose if programmes require completion of a research fundamentals course, if the research course is construction based or generic in nature, if a variety of philosophies and methodologies are included, and some indication of the assessment of student success in mastering research fundamentals. In addition, an opportunity was provided for respondents to describe other forms of support available to students.

The study was conducted utilizing a short survey administered through an internet based survey tool (reproduced in the Appendix). University BE post-graduate programmes in the US, Ireland and the UK that require completion of a research thesis was the population of interest. A list of post-graduate coordinators or chairs and their email contact information was assembled by the authors based on previous knowledge and a search of descriptions available through programme websites. The membership of the Associated Schools of Construction (ASC) was used as a guide to avoid exclusion of US based programs. A review of the membership of ARCOM was used in the case of the UK and Ireland based research degrees. A total of 22 programmes were identified and all were sent a survey.

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

4. Survey Results

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

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

Table 3 Level within the Institution the Research Courses Are Taken

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

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

It is interesting to observe this response and many possible interpretations could be inferred in regard to it. Are CM post graduate candidates seen as requiring a more social science type of research fundamentals course? Or do the research Engineers offer a more quantitative research course? A further investigation is required to get a more definite understanding.

In 11 (73%) of the cases the research fundamentals/methods course is taken for credit. This would indicate that in the majority of cases ‘learning’ the rudiments of research are integrated into the research approach. This possibly offers the motivation for students, as judged by their supervisory team, to engage at a deep level to a course of study that may be viewed by them as unnecessary. The proportion of respondents with research fundamentals/methods classes at department or programme level indicates that the preferred option is for candidates to be prepared for this aspect of the research journey at a more local level. The titles of the research fundamentals/ methods course offered in the institutions are shown in Table 4. The title *Research Methods* appears to be the preferred one. In only one case did a respondent name the title with the university coding.

Table 4 Titles Used for Research Fundamentals / Methods Courses

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

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

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

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

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

5. Discussion

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

A goal of this paper is to increase the awareness of the role that research courses play in scholarly work by providing readers with alternate means to validate research based on sound research principles. The design of any research fundamentals curriculum should address learning, teaching and assessment approaches in line with best practice and validation. Validation of the research methodology and its results is a fundamental element of the process of scholarly endeavour. Novice researchers need to be exposed to this discourse. Approaches used for BE research have included a variety of approaches. Some studies use more than one approach with emerging opportunities for research validation through collaborative efforts that utilize multiple research methodologies. Consequently, research courses should address multiple methods and related matters. The authors suspect that many faculty (lecturers) of research methods are not including adequate consideration of the pedagogical approach best suited to research courses. What is more, the scholarly literature contains few systematic discussions of curriculum design or teaching research methods; nor is there a substantial research base to inform such discussions (Garner, Wagner, and Kawulich, 2009).

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

6. Conclusions

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

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

Given the wide variety of issues still to be explored in the area of the education of researchers in research fundamentals/methods, discourse with respect to the best practice approach will be essential to future frameworks of post-graduate education. The authors encourage readers to further investigate alternate research methods by accessing some of the seminal literature sources and by collaborating across BE boundaries. The challenge is not to be "assumption free" but rather to be reflective and self-conscious of the assumptions upon which the underpinning principles operate. The BE research communit, including those new to the discipline, needs to engage in the validation, justification and discourse around a variety of research methods. While this research has evoked discourse among a small community of research active academics, there is a need to follow up with additional research and discussion.

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8. Appendix

Research Fundamentals - Survey

Part 1: Research Fundamentals - Please answer the following question

(Please note, BOS survey questions **must** be placed inside sections to work correctly)

1. Are research students required to take a research fundamentals/methods course as part of the research program/ programme? *(Optional)*

- Yes
- No

2. If students are required to take a research fundamentals/methods course is it taken at: *(Optional)*

- University level
- College level
- School/Dept. level
- Programme level
- Supervisory level
- Other (please specify)

3. Does the research fundamentals/ methods course receive credits? *(Optional)*

- Yes
- No

Part 2: Research Fundamentals - Please answer the following questions with respect to research learning and teaching details:

4. If offered, what is the title of the research fundamentals / methods course or module *(Optional)*

5. Title / Author of research course text? *(Optional)*

6.

	Yes	No
a. Are there stated learning outcomes for course/module?		
b. Is research philosophy addressed?		
c. Is research methodology/methods addressed?		
d. Are there any other research resources / research activities available to students?		

7. If you answered yes to question 6 part d, what types of resources /activities are available? *(Optional)*

Part 3: Research Fundamentals - Please answer the following question

8. Is there a formal approach to the assessment of students' research abilities? *(Optional)*

- Yes
- No

9. Are research students required to do:

	Yes	No	Other *(please specify)*
a. A research related written/oral qualifying exam			
b. A research or thesis proposal review/presentation			
c. Thesis/project minimum research requirements			

10. Are there any comments you would like to make? *(Optional)*

An empirical study of communication competence of civil engineering graduates – implication of engineering curriculums

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Abstract

Drawing upon a major revision of undergraduate civil engineering curriculum in the University of Sydney, Australia, this paper presents a graduate survey with the specific objectives to: (i) assess the graduates' communication competence; (ii) identify the important communication skills required for entry level graduate position and job promotion; and (iii) ascertain the type of effective teaching and learning activities for developing communication skills of civil engineering students. The survey findings affirm the adequacy of communication training of the revised curriculum that integrates communication across different civil engineering core courses. Also, the results show that the graduates rank interpersonal communication skills, teamwork communication skills and technical knowledge and skills as the most important communication skills for a civil engineer at the entry level and for career development. They place greatest emphasis on teaching and learning activities that aim to prepare them for industry-related experience and to gain exposure in the real work settings. These findings could be used, for comparative purposes, by other institutions that may wish to evaluate their communication training within the context of civil engineering education.

Keywords: civil engineering, communication, graduate

1. Introduction

Communication skills are one of the top criteria sought by employers in recruiting engineering graduates. Markes' (2006) review on employability skill needs in engineering shows that communication skills have appeared in all 23 lists of employability skills (required of graduates) produced, in consultation with employers, by various recruitment organizations between 1998 and 2005. Despite the importance of communication skills, many research studies highlight that there is an increasing employers' concerns about the lack of engineering graduates' communication skills development. For example, Nair et al. (2009), in their survey of 109 engineering-related employers in Australia, found that the top three graduate attributes with greatest competency gaps (i.e., difference between the reality and employers' expectation) are: oral communication skills, interpersonal skills with colleagues and clients, and written communication skills. This finding is similar to those of previous industrial recruitment surveys, indicating that engineering graduates lacked communication skills required by employers (e.g., Lang et al. 1999; Meier et al. 2000; Scott and Yates 2002). In view of this deficiency, some researchers recognised the need to align engineering curriculum development with the industry need, by looking at how engineering graduates perceive their preparedness, in terms of their communication competence, for work in the industry. For example, Martin et al. (2005) and Vest et al. (1995; 1996) have correspondingly investigated the perceptions of chemical and electrical engineering graduates about the satisfactoriness of their communication skill training and development for their professional practice. Hitherto, in response to various areas of weaknesses identified, many engineering educational research have been conducted, especially in North America, to continually look for suggestions to enhancing communication skills training in generic engineering curriculums. Some suggestions include: (i) writing across the curriculum approaches where communication instructions are integrated into most undergraduate engineering majors; (ii) interdisciplinary courses with collaborative efforts between an engineering department and a department that places strong emphasis on communication, such as English language department; and (iii) a variety of support systems including writing and communication centres and online resources (Ford and Riley 2003). In the context of civil engineering education, Pauschke and Ingraffea (1996) provide a list of innovations in undergraduate civil engineering curriculum, highlighting an increasing emphasis on communication skills in classes. In promoting the concept of collaborative teaching and learning to enhance the communication content of civil engineering courses, Koehn (2001) found that students favour the opportunities for student input rather than formal lectures. Various learning and teaching methods for interactive communication in civil engineering classrooms have also been identified in Koehn (1995). These include: the use of thought-provoking questions and class discussion, the use of group-based assignment, and the involvement of practitioners as guest speakers.

It appears that there are many other factors shaping communication training in civil engineering curriculum. Of these, a major drive is the need to meet accreditation requirements, in particular to satisfy the generic (communication) skills expected by accreditation bodies, such as the Institute of Engineers in Australia (IEAust), and the Accreditation Board for Engineering and Technology (ABET) in the US. Other factors include: (i) the diverse educational settings across institutions (Ford and Riley 2003); (ii) increasing engagement of employers and industry bodies in curriculum reform (Pauschke and Ingraffea 1996; Shah and Nair 2011); and (iii) increasing use of communication technologies by the internet and the World Wide Web.

The aim of this paper is to investigate the civil engineering graduates' perceptions of communication training in the University of Sydney, Australia. Under this aim, the specific objectives are to: (i) assess the graduates' communication competence; (ii) identify the important communication skills required for entry level graduate position and job promotion; and (iii) ascertain the type of effective teaching and learning activities for developing communication skills of civil engineering students. The results of this study will inform the main constituents of the importance of communication skills for civil engineering students, as entry level engineer graduates, and for their future career advancement. Additionally, the type of teaching and learning activities for developing the students' communication skills that are deemed the most effective will be highlighted in this investigation, which will help us promote best teaching practices in our curriculum. Likewise, these findings could be used, for comparative purposes, by other institutions that may wish to evaluate their communication training within the context of civil engineering education.

2. Context

In 2003, the civil engineering undergraduate program in the University of Sydney was revised (Airey et al. 2005). The identified drivers for the revision include: rationalisation of course offerings, changes in expectations from industry and institutions, simpler integration with civil engineering combined degrees, changing student expectations and abilities, and greater integration of generic skills development expected by the IEAust within the program. In terms of communication training, the major changes were to remove a course on "Communications" with low credit point, but instead integrated communication training with technical content across core courses. In particular, a third year course entitled "Engineering and Society" was added to the core program (El-Zein et al. 2007). It has a specific objective to improve students' communication skills and teamwork ability. The targeted survey respondents in this paper are alumni who have graduated since this major program revision.

3. Research method

A survey research design was preferred over other research designs (e.g., archival research, experimental research, and case study research) for its abilities to provide a relatively quick and efficient method to (i) obtain information from the targeted sample, and (ii) generalize the research findings based on the sample involved. However, it is recognized that the survey research design does have its major disadvantages of: (i) the low response rate, and (ii) the possible biases that arise from sampling and individual responses. Various measures were taken to deal with these shortcomings. The two major measures adopted here are: (i) the postal survey questionnaires were sent to all 230 graduates from 2007 to 2009 with local addresses, with reminder packages sent after two weeks from the initial mailing exercise in an attempt to improve response rate, and (ii) the use of official list of graduates in the sampling process (all research protocols were approved by the University's Human Research Ethics Committee prior to commencement of this study).

There are four sections in the survey questionnaire. In the first part, graduates were required to provide general information about their background (e.g., degree information, graduation year, current job). The second part is related to questions in assessing graduates' perceptions of their preparedness to 21 specific communication skills using a seven-point Likert scale 1 (not at all prepared) to 7 (excellently prepared). These communication skills can be broadly grouped into eight major categories: (i) technical writing skills; (ii) general writing skills; (iii) interpersonal communication skills; (iv) teamwork communication skills; (v) oral presentation skills, (vi) electronic communication skills; (vii) public speaking skills; and (viii) technical knowledge and skills. In the third part, graduates were asked to indicate the importance of these eight categories of communication skills (1 = not important at all – 7 = extremely important) for entry-level graduate position and job promotion. The questionnaire ends with a section on teaching and learning activities. Graduated were asked to rate the effectiveness of eleven teaching and learning activities (1 = not effective at all – 7 = extremely effective) towards developing the communication skills of civil engineer students. An open-ended feedback box was also included to provide an opportunity for other recommendations.

Apart from descriptive statistics, one sample t-test was applied to the survey dataset to test the significance of graduates' self perceptions regarding preparedness to communication skills. This was done by comparing the mean scores of the sample to a known value. Here, a test-value of 4 (i.e., the neutral score) was used to evaluate graduates' perceptions if they were adequately prepared (mean score that is statistically greater than 4), or under-prepared (mean score that is statistically below or equal to 4) for each specific communication skill. Rather than simple averaging, this provides an objective measure in identifying specific communication skills that call for immediate attention to address weaknesses in communication training.

In assessing the importance which the respondents assigned to the eight major communication skills categories for entry-level graduate position and job promotion, importance index was calculated for each category using the following formula:

$$\text{Importance index} = \Sigma \alpha X \times 100 / 7 \qquad (1)$$

where a is a constant expressing the weight given to each response, ranging from 1 (not important at all) to 7 (extremely important). $X = n/N$, with n the frequency of the response and N the total number of responses. This index helps in ranking the skills categories in accordance with their importance, and also determines any similarities or differences between entry-level graduate position and job promotion.

4. Results

A total of 32 graduates responded to the survey sent in the last quarter of 2010, representing a response rate of 14%. Despite reminder packages, it is noted that a low response rate is typical of studies involving engineering graduates (c.f. McGourty et al. 1999). (By comparison, the survey by Airey et al. (2005) on the respective curriculum revision in 2004 elicited a response rate of 13%). Table 1 shows the characteristics of the respondents that were made up of 23 males and 9 females. They were all local Australian full time students and the majority of them speak English at home (88%). In terms of degree program, most respondents were in civil engineering degree (69%), with the remaining respondents studied in civil engineering combined degrees (i.e., commerce, art, science, project engineering management). There were slightly more respondents graduated in year 2009 (59%)

than years 2007 and 2008. With an average of 2.24 years of working experience, the majority of the respondents were working on engineering related jobs (66%) at the time of the survey.

Table 1: Characteristics of graduates

Description	Frequency	% of graduates
Gender		
Male	23	71.9
Female	9	28.1
Language spoken at home		
English	28	87.5
Other	4	12.5
Degree		
Civil engineering	22	68.8
Civil engineering combined degree	10	31.2
Graduation year		
2007	4	12.5
2008	9	28.1
2009	19	59.4
First job upon graduation		
Yes	23	71.9
No	9	28.1
Job type		
Engineering-related	21	65.6
Other	11	34.4
Years of working experience		
Mean	2.24 years	

Table 2 shows the test results of the respondents' self perceptions regarding preparedness to 21 specific communication skills using one-sample *t*-test with a test-value of 4. It can be seen that the perceived preparedness mean scores for all specific communication skills grouped in: (i) general and technical writing skills, and (ii) technical knowledge and skills categories are statistically greater than 4 with *p*-value < 0.01, signifying adequate preparation in the respective communication skills. Indeed, the perceived preparedness mean scores for 'ability to apply analytic and problem-solving skills for research and inquiry' (6.13) and 'understand the technical terms used in the industry' (5.23) in the technical knowledge and skills category rank in the top three positions of the list (i.e., 1st and 3rd, respectively). The second highest scoring item is 'appreciate the importance of cooperation and tolerance in a team working environment' (5.41).

Table 2: One sample t-test of the graduates' self perceptions regarding preparedness to specific communication skills

	Test value = 4			
	Mean	Std. dev.	t	*p*-value
Oral presentation and public speaking				
Ability to collect and use accurate data to support oral presentations (e.g., using statistics published in journal articles and government reports)	4.63	1.289	2.743	0.010
Understand the use of visual aids (e.g., diagrams, photos) for effective oral presentations	4.50	1.191	2.374	0.024
Ability to incorporate appropriate oral presentation techniques (such as eye contacts and body gesture) in attracting and maintaining the attention of audience	3.88	1.289	-0.549	0.587

Ability to arrange an oral presentation in a systematic manner	4.53	1.459	2.060	0.048
Public speaking ability	4.09	1.634	0.325	0.748
Teamwork and interpersonal				
Ability to work as part of a team	5.13	1.431	4.447	0.000
Appreciate the importance of cooperation and tolerance in a team working environment	5.41	1.292	6.159	0.000
Negotiation skills to achieving mutual benefits among different stakeholders	4.31	1.512	1.169	0.251
Ability to communicate with people of different background, experiences and culture	4.66	1.428	2.600	0.014
Active listening skills to understand others and take actions based on our mutual understanding	4.69	1.256	3.097	0.004
Ability to plan and organize my work in a systematic manner	5.22	1.184	5.822	0.000
Electronic communication				
Ability to adapt to communicating and working in an automated office environment	4.31	1.378	1.283	0.209
Ability to write email messages and share real time information among colleagues regardless of geographic dispersion and time constraint	3.94	1.390	-0.254	0.801
General and technical writing				
Ability to write general reports in a concise and clear manner	5.06	1.413	4.254	0.000
Ability to write technical reports in a systematic and clear manner	5.00	1.481	3.819	0.001
Technical knowledge and skills				
Understand the technical terms used in the industry	5.23	1.564	4.363	0.000
Ability to understand technical drawings	4.68	1.326	2.844	0.008
Ability to use and research information effectively in report writing	4.91	1.329	3.859	0.001
Ability to express and organize ideas and information into knowledge for use by myself and others	5.09	1.254	4.935	0.000
Ability to communicate and present complex and technical information to a group of audience	4.81	1.447	3.177	0.003
Ability to apply analytic and problem-solving skills for research and inquiry	6.13	0.707	17.000	0.000

There are five (23%) specific communication skills with perceived preparedness mean scores that are statistically below 4 at *p*-value < 0.05 level. These are: (i) 'ability to incorporate appropriate oral presentation techniques in attracting and maintaining the attention of audience'; (ii) 'public speaking ability'; (iii) 'negotiation skills to achieving mutual benefits among different stakeholders'; (iv) 'ability to adapt to communicating and working in an automated office environment'; and (v) 'ability to write email messages and share real time information among colleagues regardless of geographic dispersion and time constraint'. This indicates that the respondents feel under-prepared in these specific communication skills, suggesting remedial action is essential to examine and improve the identified weaknesses in communication training. In particular, training in electronic communication skills where the perceived preparedness mean scores of both specific skills (items (iv) and (v)) are statistically below 4.

Table 3 shows the importance indices of the eight major communication skills categories for entry-level graduate position and job promotion. It can be seen that the top three skills categories for both entry-level graduate position and job promotion are identical. These are: (i) interpersonal communication skills; (ii) teamwork communication skills; and (iii) technical knowledge and skills. However, the interpersonal and teamwork communication skills are deemed the most valuable in job promotion, with pronounced increase in the respective importance indices. Similarly, the importance attached to both the oral presentation and public speaking skills has increased by about 6% from entry-level position to job promotion.

Table 3: Importance of communication skills for entry-level graduate position and job promotion

Communication skills	Entry level		Job promotion	
	Importance index (%)	Rank	Importance index (%)	Rank
Technical writing	25.6	5	19.7	7
General writing	22.8	7	20.1	6
Interpersonal	35.1	3	58.7	1
Teamwork	37.8	2	58.7	1
Oral presentation	25.5	6	31.7	4
Electronic	34.8	4	16.8	8
Public speaking	16.3	8	22.4	5
Technical knowledge and skills	49.4	1	52.5	3

When asked to rate the effectiveness of eleven teaching and learning (T&L) activities towards developing the communication skills of civil engineer students, all activities have recorded mean scores above 4 except role-playing activities (mean = 3.50) as shown in Table 4. It is noted that the respondents place greatest emphasis on two T&L activities that aim to prepare students for industry-related experience (i.e., industry internship, mean = 5.97) and to gain exposure in the real work settings (i.e., guest lectures from industry practitioners, mean = 5.72). This is followed by T&L activities related to oral communication skills: (i) organizing seminars; and (ii) placing greater emphasis on oral presentations, addressing the respective deficiencies noted in Table 2. The importance of these T&L activities was further highlighted in their recommendations in the open-ended feedback question.

Table 4: Recommendations on teaching and learning activities for developing communication skills of civil engineering students

	Mean	Std. dev.
Placing greater emphasis on industry internship	5.97	1.60
Inviting industry practitioners as guest lecturers to share their knowledge about the industry	5.72	1.53
Organizing seminars to improve students' oral communication skills	5.63	1.36
Placing greater emphasis on oral presentations	5.50	1.08
Placing greater emphasis on technical workshops for students to gain hands-on experience on the application of technical equipment	5.44	1.41
Organizing small discussion groups	5.19	1.28
Placing greater emphasis on technical report writing	5.09	1.53
Organizing regular laboratory sessions for students to learn basic computer applications	4.75	1.68
Placing greater emphasis on group assignments	4.53	1.50
Placing greater emphasis on essay writing	4.19	1.60
Introducing role playing activities	3.50	1.65

5. Discussion

Encouragingly, the survey findings show that the graduates are generally satisfied with the communication training in their undergraduate civil engineering program, which adequately prepared them for workplace requirements after graduation. Although there are a few specific communication skills that were perceived inadequately prepared, these skills can be taught without adding new courses to the existing curriculum, provided new teaching activities and assessment tasks aiming at developing and testing these specific skills are implemented in some courses. For example, oral presentation techniques (such as eye contacts and body gesture) should be one of the assessment criteria in evaluating student oral presentation. Similarly, e-learning platform can be used for group-based assignments where students learn to communicate electronically including: (i) setting goals; (ii) documenting progress; (iii) group editing of document; and (iv) sharing of information. These communication activities could be accounted for in grading group assignments.

Although it is recognised that graduates assign varying importance to different communication skills in their career advancement, the findings suggest that interpersonal, teamwork, and technical knowledge are skills strongly affecting new civil engineering graduates' employability and their advancement and success in industry. Indeed, the importance of these employability skills has been reported in previous studies across different engineering specialties (e.g., Vest et al. 1996; Heitmann 2003; Markes et al. 2004). The curricular implication here is that group-based projects, which simulate 'real-world' experiences, would be ideal for practising such key communication skills, and fostering a cooperative (rather than competitive) learning atmosphere to reflect the interdependency of engineers in the workplace.

In terms of T&L activities, it is not surprising that the respondents have placed greatest emphasis on industry internship. The internship could provide students with opportunities and meaningful experiences applying theories and practices discussed and applied in the classroom environment, thus enhancing their employability skills. This is consistent with Koehn (2004), who found that, via practical industry experiences, civil engineering undergraduates could better appreciate the health and safety issues and ethical considerations in the industry, and more importantly, this could bring about better student performance in their: structural engineering course, project management/scheduling and estimating course; and teamwork exercise. Likewise, Tovey (2001) suggests that the environmental, social, and cultural conditions of the workplace can help students identify their own strengths, interests, and abilities, aiding them in making decisions about their education as well as their career path following graduation. The common decisions that students in the surveyed institution have made following their industry internship are i) changes in their specialties in civil engineering, and ii) selection of elective courses related to civil engineering applications.

6. Conclusions

A graduate survey can be a useful tool in evaluating a curriculum revision. It is believed that graduates with a certain amount of post-graduate working experience can supply an informed assessment of preparedness and importance of communication training of a program. This allows engineering educators to reflect on the strengths and weaknesses of a program, and therefore to enhance the curriculum in problem areas demanding improvement.

Overall, the survey findings affirm the adequacy of communication training of the revised curriculum that integrates communication across different civil engineering core courses. The identified deficiencies in oral and electronic communication skills training could be addressed through better design assessment of communication skills and the use of group based projects in teaching. Also, the findings show that graduates agree on the importance of the same set of three communication skills for new civil engineering graduates' employability and advancement and success in industry. These skills, which relate to interpersonal communication skills, teamwork ability, and technical knowledge and skills, could be taught by: i) placing greater emphasis on teaching and learning activities that aim to prepare students for industry-related experience, and ii) promoting the role of the industry internship to gain exposure in the real work settings as recommended by the graduates. The latter requires a greater involvement of our industry partners regarding the placement and mentoring of our students during their internships.

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Conceptual understanding of sustainability in Australian Construction firms

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Abstract

Given the connection between energy use, greenhouse gas emissions and climate change and the reality that the built environment emits around half of total emissions, the construction industry has considerable potential to reduce emissions and a key role in mitigating global warming. However there is evidence that our current understanding of the concept of sustainability is fragmented and unclear. There are a plethora of terms used to cover sustainable buildings, such as ecological, green, Gaian which come in and out of fashion over time; do they mean the same thing or are they different? Furthermore do construction firms demonstrate a clear understanding of the concept of sustainability or are they muddled and confused? The consequence of unclear thinking and a lack of understanding is that ultimately the construction industry is unlikely to deliver 'sustainability' efficiently or even at all, with the broader and more onerous consequences for society as a whole. In addition what are the implications for education and should academics be broadening the debate?

Using a content analysis of published information regarding sustainability on construction company websites, this paper addresses the questions; (a)what is the conceptual understanding of sustainability within ten leading Australian construction firms and, (b) what is the implication of this level of conceptual understanding with regards to delivering sustainability?

Keywords: sustainability, Australia, construction firms, education

1. Introduction

Since the mid 1980s, the awareness of the relationship between greenhouse gas emissions and observed climate change and global warming has risen significantly. From an initial position of scepticism and denial governments and business sectors have now largely acknowledged and accepted that some action is needed to reduce greenhouse gas emissions in an attempt to mitigate the perceived impact of climate change (Stern 2006, Garnaut 2008). In this time there has been a plethora of policies and strategies debated and launched within governments at all levels as well as the adoption of corporate social responsibility within the business community across most sectors.

Construction, which involves the mining, extraction and use of resources, has a substantial environmental impact. Furthermore the type of buildings constructed impacts on the amounts embodied energy as well as the energy and water consumed during the building lifecycle, as well as materials and resources used in maintenance and repair. It is said that the built environment is responsible for around half of all greenhouse gas emissions (Wilkinson, 2011) and therefore the way in which the construction industry perceives and understands the concept of sustainability is vital to the implementation of meaningful actions to mitigate the impact of climate change.

It is said that sustainability is a contested concept; in other words it is interpreted or perceived differently by different actors; it means ‘all things to all men’ (Söderbaum 2011). If this concept is poorly understood, the actions or practices that follow may be ill-informed, misguided and ultimately will not deliver the outcomes needed (Cook & Golton, 1994). To capture the views of those organisations who have the highest construction outputs, this paper addresses the questions; *what is the conceptual understanding of sustainability within ten leading Australian construction firms and, (b) what is the implication of this level of conceptual understanding with regards to delivering sustainability?*

2. The spectrum of sustainability; ecocentrism to anthropocentrism

There is a plethora of terms used to encompass the concept of sustainability, especially within the built environment. Green, green, greener, ecological, natural, sustainable, environmentally sensitive, Gaian, and environmentally conscious design or building are some of the terms adopted by stakeholders and actors. Such varieties of terms beg the questions; do concepts overlap or are they the same? Are there some shared aspects between concepts and if so, what are they? Is the ‘sustainability’ embedded within some concepts questionable? Furthermore is it possible to conceive of a sustainable building in an absolute or a relative form? By this it is meant can a building be genuinely sustainable when considering the earth’s total resources (absolute) or, is it simply more sustainable than a building to which is it contrasted (relative)? Currently with building rating systems such as BREEAM, LEED and Green Star they are conceived as being sustainable in an absolute sense. This paper seeks to elucidate some of these questions. At the time of writing, ‘sustainability’ has become a preferred term and typically embraces economic, environmental and social considerations identified by Elkington (1997); though the term sustainability was first defined a decade earlier in the Bruntland

Report (WCED, 1987). Additionally the concept is informed by political and philosophical thought, and all aspects were taken into account within a literature review. The literature revealed that there are distinct characteristics and sub groups within the concept of sustainability which needed to be de-constructed and ordered to clarify shared characteristics and those which were separate.

A key division between the groups is ecocentrism and anthropocentrism (Pepper 1984, Dobson 1990, Brown 1995). In summary an ecocentric world view perceives ecosystems as part of an integrated environmental system with organisms, biological communities and ecosystems creating the mantle of life surrounding the planet. Ecocentrism is advocated by an environmental movement known as Deep Ecology (Naess 1990, Brown 1995) and is grounded in seeking the common good of the human and non-human world (Purser & Montuori, 1995). In addition ecocentrics are radically egalitarian where entities such as animals, humans, rivers, seas and lakes are all believed to have equal and intrinsic value. Ecocentrics' argue that only when this world view is adopted will we substitute environmentally destructive policies for more benign policies. Paradoxically in asking humankind to take responsibility for whole of the ecosphere eccentrics' are expressing anthropocentrism. Furthermore in reality, the egalitarian ecocentric world would collapse into nihilism if no distinctions of value are made where for example the value of a child in a ghetto tenement is equal to that of a family of rats (Brown, 1995). Taken to the extreme, there is a concern that ecocentrism lends itself to an ideology of domination, where eco police enforce eco policy (Dobson, 1990). Whilst some reduction in mankind's interference with the ecosphere is desirable, it is argued that some forms of ecocentrism would lead to the rejection of human rights in favour of the ecosphere, for example propositions of a human population cull advocated by the transpersonal ecology group (Naess, 1990). Within social and political system ecocentrics tend to dislike centralised systems and materialism (Cook & Golton, 1994) and this is a stance which puts them at odds with current prevailing paradigms.

The dominant world view has been anthropocentric, where mankind is perceived to have a dominant role, only humans possess intrinsic value, and are the rightful masters of 'nature' as well as being the origin and source of all values (Cook & Golton 1994). As such, anthropocentrism is a very different world view to ecocentrism (Brown 1995). It is contended that to deliver sufficient sustainability to avert overwhelming levels of climate change, it is necessary "to persuade civil society to make a break from the anthropocentric perspective where the environment affects and benefits humans" (Salinger 2010). Within the anthropocentric paradigm resources are extracted without replenishment and non-reusable materials such as plastics and nuclear waste accumulate. Some argue that anthropocentrism is based in the positivist, objective thinking characteristics in our scientific, mechanistic and technological world view which emerged from the 17th century onwards (Brown, 1995). Anthropocentrism is held by ecocentrics to be the root cause of the ecological crisis (Cook & Golton, 1994). Anthropocentrics believe that mankind is able to provide a technological fix to the environmental problems and another term for this approach is technocentric (Cook & Golton, 1994).

However it is too simplistic to see a clear divide between ecocentrism and technocentrism, as in real life the boundaries are blurred and the issues are complex (Pepper, 1984). One issue between an ecocentric worldview as opposed to an anthropocentric one is; where does the line between fair use and abuse lie (Purser and Montuori 1996)? Or where does economic development become exploitative? Furthermore authors such as Pearce (1993) and Pepper (1984) perceived further sub groups or categories within ecocentrism and anthropocentrism. Within anthropocentrism those on the left, known as ‘accommodating environmentalists’ tend to be gradual reformers believing in careful economic and environmental management but without radical change to social economic and political structures (Cook & Golton, 1994). Those on the right are known as ‘cornucopian environmentalists’ believe in unfettered economic growth and humankind’s right to utilise the worlds resources as they see fit. Within the ecocentric camp there is a divide between those on the right; ‘deep ecologists’, who put a greater emphasis on the limits to growth or carrying capacity of the earth, and those on the left ‘moderate ecologists’ who believe in decentralised political and social institutions. Deep ecologists believe in compulsory restraints on human population growth and on resource consumption.

Economically anthropocentrics belong to the neo classical school, believing that economic growth is possible, they reject intervention in the economy to tax or incentivise sustainability measures. There is evidence that this stance is beginning to change and evolve in capitalist economies with an increase in the scope of environmental legislation. For example, in 2010 the disclosure of energy consumption in commercial buildings in Australia became mandatory (Warren & Huston, 2011) and in the UK similar legislation, known as Energy Performance Certificates (EPCs), was mandated in 2007 (DirectGov, 2012). A more contentious legislation in Australia is the introduction of a carbon pricing mechanism which is due to commence in July 2012, the notion of ‘taxing’ carbon pollution met with significant resistance in the Australian parliament during 2011. There was concern about the potential impact on the economy and the amount of the carbon price compared to other countries; it remains to be seen how the policy is accepted by the electorate in the forthcoming 2013 election. To date the Australian government has largely offset the potential negative political and economic impacts of the pricing mechanism with generous government assistance to households. It is hard to say whether there is a temporary or permanent shift in the neo classical economic philosophy adopted by cornucopian environmentalists towards an economic outlook more attuned to accommodating environmentalism. In Australia, it is possible that this carbon pricing policy has resulted from a coalition government of the Labour and the Green party and represents the compromise Labour were prepared to make for political leadership. What is a concern is that within the built environment improved economic performance through a perceived increase in capital value is the main argument used to persuade property owners and investors to adopt sustainability (Eichholtz et al 2009, Fuerst & McAllister 2011, Newell 2008). In summary a spectrum of ideas and values exists within the concept of sustainability which goes from dark green to light green, or as some have suggested to grey; implying that the pursuit of weak sustainability does not deliver sustainable outcomes (Söderbaum 2011. Cooper 1994). The range of standpoints identified in the literature is expressed in Table 1 below. Five distinct groups were identifiable with two classified as anthropocentric (accommodating and cornucopian environmentalism) and three being ecocentric (transpersonal, deep and moderate ecology).

Table 1: Ecocentric and anthropocentric standpoints. *(Source: Author)*

Stand-point	Transpersonal ecology	Deep ecology	Moderate ecology	Accommodating environmentalism	Cornucopian environmentalism
Belief system	Religious level of belief	Bio-ethics and intrinsic value	Primary value of ecosystems	Intra and inter-generational equity	Support for traditional ethical reasoning
				Instrumental value in nature	Rights of humans
		Accepts ‘carrying capacity’ of earth argument	Accepts ‘carrying capacity’ of earth argument		
	Emotional and irrational			Rational and pro science	
		Lacks faith in technology			Faith in science and technology
Population	Population cull	Reduce population	Zero population growth	Silent	
Resource consumption		Extreme preservationist	Resource preservation	Resource conservationist	Resource exploitative
World view	Ecocentric			Anthropocentric	
	Lacks faith in technology				Faith in technology
Waste	Reuse, repair and then recycle			Recycle	
Economic	Capitalism is not sustainable. Rejects consumerism.	Heavily regulated economy. Capitalism is not sustainable. Do not favour overseas trade. ‘eco’nomics. Rejects consumerism	Zero economic growth. Capitalism is not sustainable. Do not favour overseas trade. ‘eco’nomics. Rejects consumerism. Little overseas trade.	Managed growth. Capitalism is sustainable. Consumerism is acceptable. Overseas trade is acceptable.	Maximise growth. Capitalism is sustainable. Substitution theory prevails. Laissez faire economics. Green consumerism is accepted. Promotes consumerism. Promote foreign trade /

		Little overseas trade.			agreements
Energy	Preservationist	Preservationist	Conservationist	Conservationist	Nuclear is acceptable, conserve and increase consumption
	Very strong sustainability		**Strong sustainability**	**Weak sustainability**	**Very weak sustainability**

In Table 1 it is apparent that the most radical group, the ‘transpersonal ecologists’ are so embroiled in ecosophical arguments and debate that they are unable to form a coherent group who are capable of action (Dobson, 1990). The ‘deep ecologists’ and ‘moderate ecologists’ share a number of beliefs but also have distinct and separate positions on some issues, for example, both groups believe capitalism is not sustainable. However ‘deep ecologists’ believe in bio-ethics and in the intrinsic value of nature whereas ‘moderate ecologists’ believe in the primary value of ecosystems; a less extreme view. A similar situation prevails for the anthropocentrics, the environmentalists. The two anthropocentric groups share views on the value of science and rational thought. They differ on the ‘rights of humans’ which dominate for the ‘cornucopian environmentalists’ however for the ‘accommodating environmentalists’ there is instrumental value in nature. Another way of presenting these beliefs and standpoints figuratively is shown in figure 1 as the spectrum of sustainability concepts.

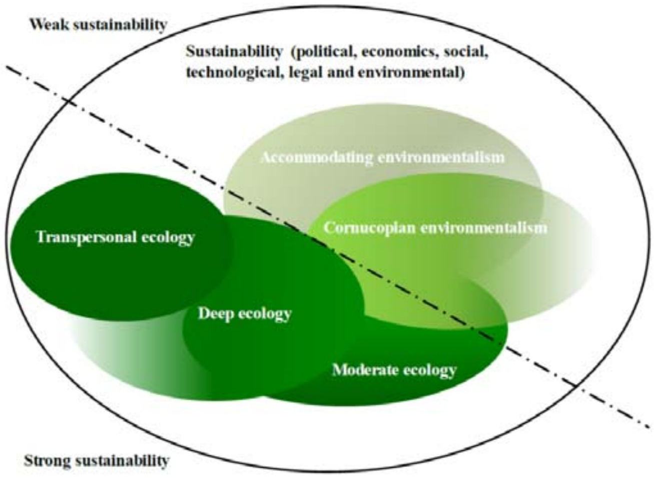

Figure 1.The spectrum of sustainability concepts. (*Source: author)*

Figure 1 illustrates the disconnect between transpersonal ecology and anthropocentrism / environmentalism. Elsewhere there is some overlap between the groups in their value systems and beliefs. There is a broader divide between ecocentrism and anthropocentrism where one is considered to deliver strong sustainability and the other weak sustainability. The question is: is weak and very weak sustainability going to deliver sufficient changes for the generations to come and those already here? Brown (1995) asserts this level of sustainability will fall short of what is needed. The built environment is responsible for significant environmental impacts. Buildings use resources during construction with the extraction of resources, energy and water resources are used in the transport and manufacturing of construction materials and components. Considerable amounts of waste are also created at this stage. During the building's operational phase energy resources are used in lighting, heating and cooling and water is used in building services. Occupant or building user health is also impacted by the materials used during construction. At the end of the building lifecycle, unless materials are re-used or recycled, they will be transported to landfill where the resources are lost in perpetuity.

Within the built environment, construction companies are a sub group who have an impact on the sustainability of the buildings that they construct, design and sometimes operate and in this regard their conceptual understanding of sustainability is very important. It has become a current practice for many organisations, and not just construction companies, to adopt 'corporate social responsibility' or CSR as a means of organising, structuring, managing and reporting their environmental impact (Wilkinson et al, 2004). As a requirement of CSR companies provide information about their sustainability targets, policies and strategies, usually on their websites. This information is deemed to be an accurate and unbiased account of their respective stance and attitudes towards sustainability. Figure 2 adapts figure 1 and shows construction companies as a sub set of built environments. Other actors within the built environment include designers, building users, owners and policy makers however their conceptual understanding, though important and collectively significant, is outside the scope of this study.

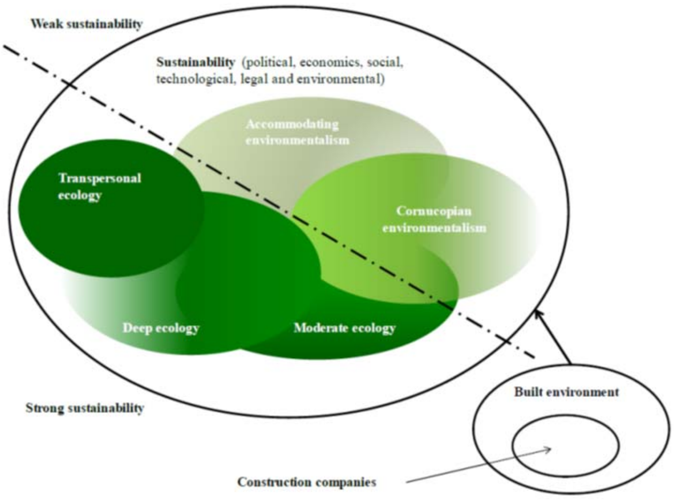

Figure 2.The relationship of built environment and construction companies to the spectrum of sustainability concepts. (*Source: author)*

3. Research questions and methodology

This research poses two questions; *(a) what is the conceptual understanding of sustainability within the ten leading Australian construction firms and, (b) what is the implication of this level of conceptual understanding with regards to delivering sustainability?* This pilot study is a qualitative research project which follows an inductive approach to generating hypotheses with a view to gaining a greater understanding of a concept of issue rather than hypothesis testing (Silverman, 2000). The researchers commenced with the notion that current understanding of the concept of sustainability may be variable within the Australian and UK construction industry. The research is qualitative; in that it analyses words and not numbers, there is a preference for naturally occurring data (here company website content), a preference for meaning (trying to understand the world from the perceptive of those studied) (Silverman, 2000). There is a danger in interviewing individuals with regards to sustainability that the interviewer is exposed to the 'company' line on sustainability or the interviewee gives the answers they think the interviewer would like to hear. Using information that is in the public domain neatly sidesteps this problem and gives the company viewpoint on sustainability. Though of course it does not permit the researcher to delve deeper and probe for further explanation on any given issue. The researcher is left to interpret the information provided in the context of the spectrum of sustainability.

Although the research is qualitative the method used to analyse the data is quantitative; content analysis (Silverman, 2000). In content analysis a set of pre-determined categories are used to count content; in this case the publicly available content of construction company websites outlining the company understanding and position in respect of sustainability. Content analysis is a flexible method for evaluating textual data which is particularly useful when existing theory or literature is limited (Hsieh & Shannon, 2005). Rather than risk bias from interviewing individuals representing the companies it was decided that a content analysis of websites and company reports was a more appropriate method to adopt. Here content analysis is used as a means of describing company or organisational conceptual understanding of sustainability. The websites and reports are an un-restrained environment in which companies are able to promote to others their understanding of the importance and scope and depth of sustainability in the built environment. Research using qualitative content analysis focuses on the characteristics of language as communication with a focus on content though it goes beyond counting words to examine language intensely for the purpose of classifying a large amount of text into a manageable number of categories that represent similar meanings (Hsieh & Shannon, 2005). The websites and reports present the public face of sustainability within the top or largest construction companies that this research investigates. In this respect the data allows the researchers to 'narrate' the concept of sustainability through the company's eyes (Silverman, 2000).

Ten construction companies from Australia were randomly selected from a list of the top 50 construction companies. Knowledge generated from content analysis is based on organisations perspectives and grounded in the actual data (Hsieh and Shannon, 2005). Objective criteria were selected from the literature review to reflect corporate or company perspectives and attitudes towards sustainability. These terms were coded and used as a basis to analyse text. For each company a search was undertaken for a sustainability statement or CSR report or environmental management plan which would set out the company policy, strategy and views in respect of sustainability. Content analysis is an accepted method of conducting qualitative research and data analysis. Theory building is possible following the analysis of the data. The analysis is structured in terms of the themes concepts and categories may be understood for the companies and similarities and differences are highlighted and explained. The coding for the analysis followed the criteria identified in the literature review and where possible the interpretation is triangulated with the literature.

4. Data analysis and discussion

The companies are not identified in this paper as the purpose is to investigate the different conceptual understanding as publicly stated. Each company was given an alphabetical label. Of the ten companies eight are global international companies with offices and operations in Europe, Asia, the Middle East and America. Some of the companies were active across a range of mining, construction and services whilst others focussed on construction only. Head offices were located in Victoria, South Australia, Western Australia and NSW. Employee numbers ranged from 5000 to 17,000 and company turnover, where published from, $350 million to $8 billion. Half the companies had formally adopted corporate social responsibility (CSR) but all mentioned sustainability or environment. The diversity of the companies reflects a varied range of State and local influences as well as broader Australian and global influences.

As part of the content analysis the number of times the words sustainability, CSR, growth (economic), sustainable growth, and sustainable occurred was measured. There was considerable variation. In company B for example, the company values did not include sustainability and the word appeared seven times in the annual report often in the context of ‘sustainable’ jobs for indigenous people and safety issues. In contrast, the word growth in the context of economic expansion appeared 47 times. Such content reflects the importance attached to sustainability and to a neo classical economic outlook towards economic growth and expansion. There is little thought given to the resource consumption needed to accommodate that growth and the conflict it creates within the paradigm of sustainability. On the other hand examination of company H materials found much higher rates of usage of the word sustainable and sustainability throughout all parts of the website and company reports. This company has a much broader understanding of sustainability and it appears more embedded throughout the company philosophically and practically, although it is still placed within the anthropocentric grouping. Company H’s website stated that they aimed to do ‘meaningful work that protects our environment’, supports ‘responsible economic growth’ and ‘improves the quality of peoples lives’; and this a very progressive and enlightened position especially when compared to the mission or value statement stated by the other companies.

Further analysis of the data revealed that all the companies were silent on a number of issues which were as follows; bio-ethics and intrinsic value, primary value of eco-systems, instrumental value in nature, rights of human beings, carrying capacity of the earth, resource preservation, ecocentrism, the sustainability of capitalism, sustainability of consumerism, advocating for zero economic growth, energy preservationist and population issues.

Table 1 illustrated the groupings associated with the issues listed above within the spectrum of the conceptual understanding of sustainability. It is apparent that there is a complete lack of awareness, acknowledgement and engagement with a significant number of important issues within the concept of sustainability. Typically these perspectives are those adopted by the ecocentrics; that is transpersonal, deep and moderate ecology. Do construction companies need to raise their awareness, acknowledge and engage in some of these issues? In the authors view they do, if only to then reject them; at the very least they would be making an informed choice. Table 2 shows a selection of the companies viewpoints stated in respect of the issues that did fall within their conceptual understanding. The bracketed initials in the first column of the table shows whether the view is a deep or moderate ecology, cornucopian or accommodating environmentalist perspective. In the ranking process; where it is a view shared by more than one group the company's perspective and context in which the view was expressed was taken into account and classified accordingly. The table illustrates the variety of positions taken by these companies and that indeed the spectrum of sustainability is reflected in these companies.

Table 2 Company views on various sustainability issues. (Source; Author)

Construction company	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Growth mentioned (CE/AE)	CE	CE	CE	AE	CE		AE		CE	CE
Neo-classical economic outlook (CE)	CE	CE	CE	AE	CE		AE		CE	CE
Intra and inter-generational equity (AE)			AE		AE		AE			
Support for traditional ethical reasoning (CE)	CE	CE		CE	CE		CE		CE	CE
Rational and pro science (AE/CE)	AE/ CE	AE/ CE		AE/ CE	AE/ CE				AE/ CE	AE/ CE
Lacks faith in technology (DE/ME/AE)									AE	
Faith in science and technology (CE)	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE
Resource conservationist (AE)			AE	AE		AE				
Anthropocentric (AE / CE)	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE
Recycle (AE / CE)		AE / CE		AE / CE	AE / CE		AE / CE			
Maximise growth. Capitalism is sustainable. Substitution theory prevails. Laissez faire economics. Green consumerism accepted. Promote	CE	CE	CE		CE	CE				

consumerism & foreign trade agreements. (CE)										
Energy – Conservationist. (ME / AE)	AE	AE					AE		AE	
Energy - nuclear is acceptable, conserve & increase consumption (CE).	CE	CE			CE					
Silent on population (AE / CE)	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE	AE / CE

From the data analysis, figure three (below) was produced to plot the collective positions of the companies and their conceptual understanding as expressed on the websites and in their company reports.

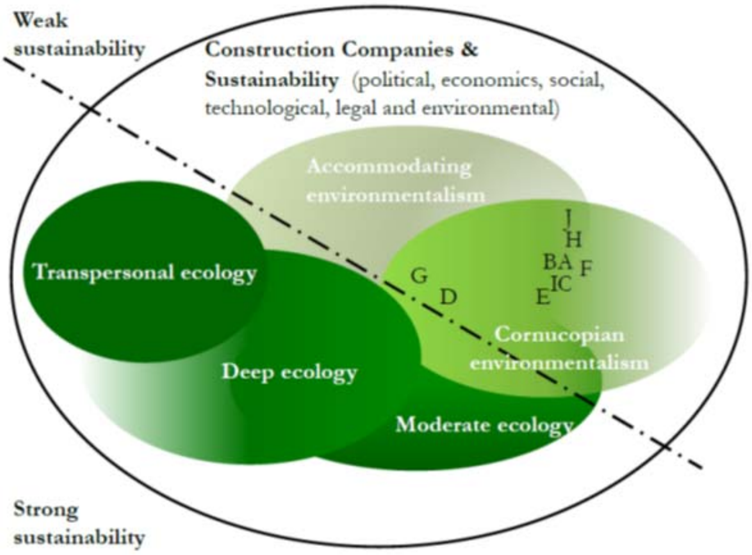

Figure 3. Conceptual understanding of the construction companies with the spectrum of sustainability concepts. (*Source: author)*

5. Conclusions and further research

This research posed two questions; *(a) what is the conceptual understanding of sustainability within the ten leading Australian construction firms and, (b) what is the implication of this level of conceptual understanding with regards to delivering sustainability?* This pilot study has shown that there is variance in the conceptual understanding of Australian construction companies; and that it is as Cook and Golton noted; 'an essentially contestable concept' (Cook & Golton, 1994). On a positive note there are encouraging signs that some of the positions advocated by accommodating environmentalism are gaining traction and this reflects a shift from the findings of Cook & Golton's study of the UK construction sector in the early 1990s (Cook & Golton, 1994). In answer to research question two, to date none of the companies are adopting any ecocentric perspectives and this would indicate that we are in a position only to deliver weak sustainability from this sector at this point in time. Given that Brown (1995) has stated that weak sustainability will not, in itself, provide the solutions to the problem humankind is facing; there are significant issues that we need to address as an industry, as individuals and as a community. For all our green rating tools and schemes we are, with our current level of understanding of sustainability, in imminent danger that we will hit the targets but miss the point.

Academics have a responsibility to be informed about sustainability and to broaden the perspectives of the students they teach. If our industry has a limited perspective and understanding of the concept at present, we should as academics endeavour that the industry leaders of the future are equipped to make more informed evidence based decisions. This paper has reported the findings of an initial pilot study examining the conceptual understanding of sustainability within the Australian construction sector. This pilot study will be re-examined using NVivo to undertake a computer based content analysis and secondly using a technique called Multi-dimensional Scalogram Analysis (MSA) which is used by environmental psychologists to understand how people view 'issues'. The two approaches will then be contrasted to examine outputs. Given that only two of the ten firms operated in Australia exclusively it is apparent that the study should be expanded to include construction companies globally. In addition the construction companies are a sub set of the sector and further work is required to investigate the conceptual understanding of the other stakeholders.

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Is education in lean construction leading or lagging?

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Abstract

Lean Construction (LC) has rapidly increased its popularity among the major contractors in the Danish Building industry. Research indicates however that some contractors have more LC in their mouth than in their hands so to speak. A main reason for this is likely that knowledge and competences in terms of LC principle and tools is missing at the contractors. Several of the large Danish contractors have internal educational programmes aiming at learning employees at all levels LC. Also Leanconstruction.dk offers training in LC methods. One might ask if we have reached a local optimum with the current state of LC knowledge available through different educational programmes.

The most effective way to achieve increased knowledge in the building industry is to disseminate knowledge through traditional educations from Vocational training through Bachelor, Master and PhD programmes. This paper looks into how well LC is implemented and teached in the Danish educational programmes surrounding the building industry. Hence, the purpose of this paper is first to identify LC teaching at all educational levels throughout all relevant Danish schools, college universities and universities. This investigation will include both amount and topics. Secondly to investigate how well LC is adopted and applied in the Danish building industry. Thirdly, to discuss the findings and put forward the consequences of this (mis)match, and finally to propose directions for both educational institutions and practitioners.

The research has collected data from all relevant Danish institutions in terms of syllabus, course descriptions and clarifying interviews with lectures when needed. Data from the industry has also been collected through a questionnaire, interviews with key stakeholders and through Leanconstruction.dk

Keywords: Teaching, Lean Construction, Knowledge, Lean practice

1. Introduction

Lean Construction (LC) has rapidly increased its popularity among the major contractors in the Danish Building industry. Research indicates however that some contractors have more LC in their mouth than in their hands so to speak. A main reason for this is likely that knowledge and competences in terms of LC principle and tools is missing at the contractors. In a wider perspective the differences between intended and actual application of theory is important. The risk of insufficient or non-intended application is a general issue and should be treated with great awareness when designing or implementing theory. This research is, therefore, transferable and of great importance to general project management.

From an educational viewpoint it is relevant to know whether the competencies and knowledge teached at Universities, and University Colleges is leading or lagging. If teaching is lagging there will raise a quest for after education. Often this quest is overseen, and there will lack knowledge in the industry, which again can result in poor performance and lost development opportunities. Opposite, if education is leading, it might result in that knowledge is not applied in practice, and that this unused knowledge is substituting other areas of knowledge which might have been more useful to industry. The author's viewpoint is that there shall be some kind of equilibrium with a slight tendency for teaching to be leading.

The research question is simply: Is education in Lean Construction leading or lagging the construction industry?

1.1 The educational framework

In general the educational level is high in Denmark. EHEA, a Bologna follow-up group secretariat, is leading the continuous change toward transparency in the higher education area. They also keep track on each country's progress in the Bologna Scorecard. In the latest report from 2009 (Rauhvargers *et al.*, 2009). Denmark placed second in fulfilling the declaration, right after Scotland. Only implementation of the National Qualification Framework is not yet 100% in the Danish rating.

In this research the focus is on the comparable grade structure, known as the 3+2 system. The purpose is to grade the higher educational area in 3 year bachelor (both Bachelor of Science and Professional Bachelor), and a 2 year Master.

Figure 1 show an overview of the complete Danish educational system, and points out which parts are entailed in the research.

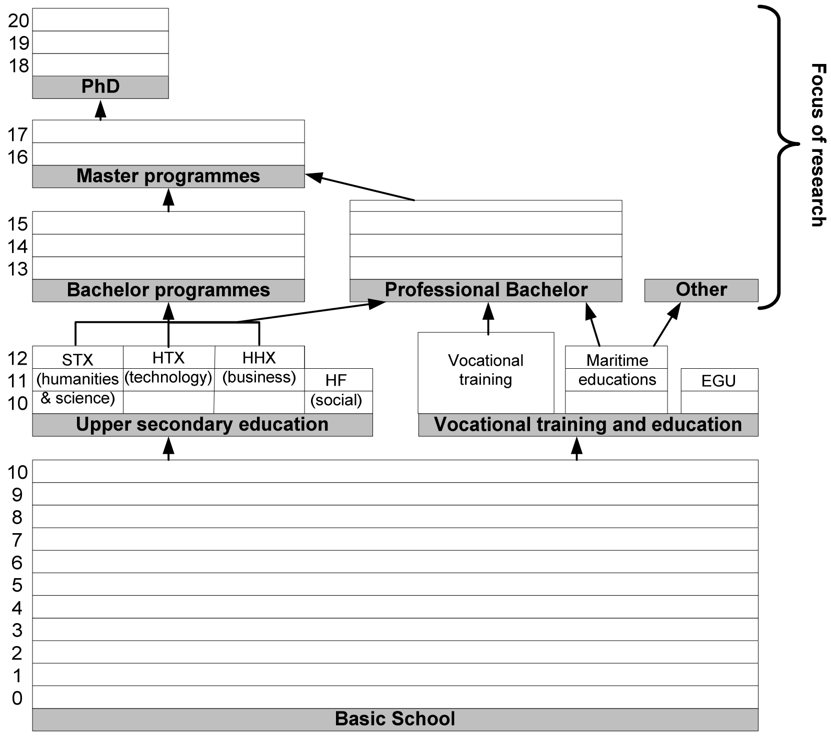

Figure 1: The educational framework in Denmark, and the focus of this research

This research narrows the focus to higher education, which includes academic and professional bachelor programmes, Master programmes and PhD. This delimitation is chosen of several reasons. Firstly, the lower part of the educational framework is general and not construction orientated. The likelihood of finding LC in curriculum is low, and does not counterbalance the effort in data collection. Secondly, this delimitation is equivalent to the undergraduate and graduates studies in e.g. the US. Thirdly, it increases the possibility of validation and international comparison

2. Methodology

This research is an explorative research aiming at identifying real life actions. The purpose was A) to identify in which extend Lean Construction is taught at Danish Universities, and B) to identify the current status of Lean Construction adaption and implementation at Danish practitioners.

The process of identifying Lean Construction in the educational systems was divided into the academic levels of Ph.D., M.Sc., and B.Sc. All Danish Universities and University Colleges were applied in the research. For all levels the data collection method was as follows:

- Search in online course catalogs (both current and past if available), and search in course description. The search looked for these keywords: Lean, Lean Construction, Planning, Scheduling, Project Management and Construction Project Management.
- If any of these keywords was identified. The findings are validated by contacting the course responsible.

To investigate the application of Lean Construction an online questionnaire survey was conducted in ultimo 2011. The questionnaire was devised with outset in designing theory presented in Forza (2002). In total 192 persons were included in the survey. It is considered acceptable that the same firm contributes to the survey with multiple questionnaires. The questionnaire was completed by 14 project managers, 17 construction managers, 16 site managers, 7 foremen, and 5 participated without stating their position. The selected participants cover the different levels of scheduling in a construction project. They represent varying opinions and contribute with different experience to scheduling. This secures an unbiased and valid survey. The questionnaire process takes its outset in the strategy presented in Akintoye and MacLeod (1997).

The survey proceeded as follows. First, an initial invitation was sent out to every participant and after two weeks a reminder was sent out to those who had not yet completed the survey. In total 59 persons completed the survey resulting in a response rate of 31%. The response rate is thus above the critical response rate of 20% (Malhotra and Grover, 1998). The questionnaire is constructed of successive questions where respondents continuous are sorted and depending on the answers can be discarded.

Therefore, the number of respondents will vary from question to question. No completed questionnaires have been rejected by the authors due to incorrect answers.

3. Lean Construction in Education

The following paragraph show the results of the survey divided into academic levels of Ph.D., M.Sc. and B.Sc. The findings are shortly comment, and later discussed in comparison to lean integration in practice.

3.1 PhD programs

All doctoral schools in Denmark within fields of technical, science and social science were identified and included. 10 doctoral schools obeyed these criteria. Findings are illustrated in table. 1.

Table 1: Lean Construction courses at Ph.D.-level at Danish Universities.

Doctoral school and programs	***Courses with LC***	***Data source***
The Doctoral School of Engineering, Science, and Medicine at Aalborg University	*No courses or course elements with LC theory*	*Online course catalogue*
PhD School of Social Sciences at Aalborg University	*No courses or course elements with LC theory*	*Online course catalogue*
Graduate School of Science and Technology at Aarhus University	*No courses or course elements with LC theory*	*Website*
Graduate Schools at Aarhus University Business School	*No courses or course elements with LC theory*	*Website*
PhD Schools at Copenhagen Business School	*No courses or course elements with LC theory*	*Website*
Management in Engineering at DTU	*No courses or course elements with LC theory*	*Online course catalogue*
University of Southern Denmark	*No relevant doctoral school, hence no courses or course elements with LC*	*Website*

Roskilde University	*No relevant doctoral school, hence no courses or course elements with LC*	*Website*
The Danish Doctoral Schools of Architecture & Design	*No courses or course elements with LC theory*	*Website*

As table 1 clearly shows, there are no course with lean construction, either as whole courses or as course parts. The authors are though acquainted with Ph.D.-students work with different parts of lean in construction.

3.2 Master (M.Sc.) programs

Danish universities who offer civil engineering, construction management, and architectural studies are included. In total five universities in Denmark is included in the research. The finding on Master level is illustrated in table 2.

Table 2: Lean Construction courses at Master level.

University and programs	***Courses name***	***LC description***	***Data source***
Aalborg University, Cand.Scient.Techn. in construction management	*Project management and economics*	*Introduction to Lean Construction in general, and in depth on LPS. Estimated to 0,25 ECTS. A part of a course.*	*Online course syllabus and interview with course responsible*
Aalborg University, SBI department, Cand.Scient.Techn. in BIM and construction mgmt.	*Change management in construction*	*Introduction to Lean Construction. Estimated to 0,25 ECTS. A part of a course.*	*Online course description and e-mail correspondence with course responsible*
Danish Technical University, M.Sc. in engineering	*Project based production (optional course)*	*Lean Construction as a management concept; implementation and change management. Estimated to 0,25 ECTS. A part of a course.*	*Online course catalogue and e-mail correspondence with course responsible*
Danish Technical University, M.Sc. in engineering	*Construction management and planning*	*LC theory and methods, LPS and PPC, LC in a national planning perspective. Estimated to 0,25 ECTS. A part of a course.*	*Online course catalogue and e-mail correspondence with course responsible*

As table 2 illustrates, only two Danish universities have courses on Master level with Lean Construction elements, namely Danish Technical University and Aalborg University. In both cases, Lean Construction is fitted into larger course on construction management related topics.

3.3 Bachelor programs

In this section both academic bachelor programmes and professional bachelor programmes is included. All Danish Universities and University Colleges offering construction related programmes are included. Hence this part includes 5 universities and 7 university colleges. The finding on Bachelor level is illustrated in table 3.

Table 3: Lean Construction courses at Bachelor level.

University and programs	**Courses name**	**LC description**	**Data source**
Aarhus University, B.Sc.Eng in Civil and Structural Engineering	*Building processes*	*Introduction to lean construction, planning and LPS. Estimated to 0,5ECTS. A part of a course.*	*Interview with course responsible*
Copenhagen University College in Engineering, B.Sc.ACTM[1]	*Construction Management*	*Introduction to lean construction, planning and LPS. Estimated to 0,5ECTS. A part of a course.*	*Online course descriptions and e-mail correspondence with course responsible.*
Copenhagen University College in Engineering, B.Sc.ACTM	*Construction Planning and Cooperation*	*Development of Process plans. Estimated to 0,1 ECTS, and a part of a course.*	*Online course descriptions and e-mail correspondence with course responsible.*
Danish Technical University, B.Sc.Eng.	*Planning and management of Construction*	*Planning of time and logistics in relation to lean principles. Estimated to 0,4 ECTS and a part of a course.*	*Online course catalogues and e-mail correspondence with course responsible.*
University College of Northern Denmark, B.Sc.ACTM	*LC is integrated throughout the education, and small pieces is applied in each semester*	*Introduction to LC, LPS, Value for client and Lean Design. Estimated to 1, 0 ECTS, small parts in several courses*	*E-mail correspondence with course responsible.*
VIA University College, B.Sc.Eng.	*Production planning*	*Half of a course is assigned LC. LC in general, LC principles, LC tools, LPS, PPC, etc Estimated to 2,0 ECTS, and part of a course*	*E-mail correspondence with course responsible.*
University of Southern Denmark, B.Sc.Eng.	*Construction Management (optional course)*	*Introduction to Lean Construction. Estimated to 0,25 ECTS, and a part of a course.*	*Online course catalogue and e-mail correspondence with course responsible.*
Aalborg University, B.Sc. in Civil Engineering.	*Project management and economics*	*Introduction to Lean Construction in general, and in depth on LPS. Estimated to 0,25 ECTS. A part of a course.*	*Online course syllabus and interview with course responsible*

Table 3 illustrates that Lean Construction is well rooted on Bachelor level. Most of the programmes have an introduction to Lean Construction principles. Only one educational institution has integrated Lean Construction throughout several semesters. University College of Northern Denmark, have split Lean Construction into small pieces and provides on piece in the puzzle for each semester. At Danish Technical University, students can have more than one course with Lean Construction elements, which should grant them the highest level of Lean Construction education in Denmark.

[1] ACTM is a acronym for Architectural Technology and Construction Management

3.4 Additional results

Many of the interviewed course responsible acknowledged that Lean Construction not is paid sever focus in their programmes, but that it in recently years is an integrated topic taught in relation to Construction Management. They also comment on that many students have great interest I Lean Construction, and therefore seek to involve this topic in their group work and/or in their theses. This tendency is confirmed both by the Danish association of lectures in construction methods and management and by LeanConstructio.DK. The latter has a yearly contest where students can submit theses working with Lean Construction. The submission is not overwhelming, but present.

4. Lean Construction in Practice

One thing is theory and the intended use of Lean Construction, another is the practical application of the system by practitioners. To detect differences between theory and application, a questionnaire was designed. First of all, the questionnaire showed a general lack of knowledge of lean construction. When asked *"how does Lean Construction see production"* 78.1% did not think transformation, 28.1% did not think value creation, and 18.8% did not think flow as a part of the lean construction view of production. The survey looked more specific into the application of LPS, which is the most applied Lean Construction tool at present. The LPS approach consists of a set of elements, which together ensure a reliable schedule. The questionnaire revealed that LPS is not applied as a complete system. Instead only parts of LPS are applied. Combined with the general lack of knowledge this is considered to be one of the barriers towards a more reliable schedule. The results of the question *"which elements of Lean Construction have you applied"* can be seen in Table 4 Especially, learning and pulling is rarely applied.

Table 4: Which elements of Lean Construction have you applied?

Element	***Respondents (n=)***	***Percent (n/N *100 =)***
Weekly work plan	*34*	*91.9%*
Look-ahead plan	*32*	*86,5%*
Phase schedule	*31*	*83,8%*
Master schedule	*30*	*81,1%*
The seven preconditions	*25*	*67,6%*
Sequencing (post-it)	*20*	*54,1%*
PPC	*18*	*48,6%*
Pulling (Just-In-Time delivery of materials)	*14*	*37,8%*
Buffering	*12*	*32,4%*
Learning (PPC)	*11*	*29,7%*
Total (N=)	*37*	*100%*

The respondents were also asked if failures in the making ready for conduction process where a consequence of lacking knowledge. These results are illustrated in table 5.

Table 5: Is failure in the making-ready-process caused by lack of knowledge?

	Respondents (n=)	***Percent (n/N *100 =)***
To a very high degree	*4*	*11,4%*
To a high degree	*16*	*45,7%*
To some degree	*4*	*11,4%*
To a lesser degree	*4*	*11,4%*
Not at all	*3*	*8,6%*
Do not know	*4*	*11,4%*
Total (N=)	*35*	*100%*

Lean Construction is based on continuous search of excellence, which implies that learning cycles is an important part of Lean application. At present time, the most applied learning tool in Lean Construction is PPC measures and evaluation of these. Table 6 show respondents trust in PPC measures as learning tool.

Table 6: Do you trust in PPC as learning tool

	Respondents (n=)	***Percent (n/N *100 =)***
To a very high degree	*1*	*3,0%*
To a high degree	*11*	*33,3%*
To some degree	*11*	*33,3%*
To a lesser degree	*6*	*18,2%*
Not at all	*1*	*3,0%*
Do not know	*3*	*9,1%*
Total (N=)	*33*	*100%*

5. Discussion

Since this is national investigation of Danish conditions, some international perspectives is put forward to increase the transferability of the results. No thorough investigation of either LC integration in education or LC implementation in practice do exists. It is also out of scope for this research to carry out such a research, hence the following is only a brief overview on LC worldwide in practice and in education.

5.1 Industry take up of Lean Construction

Lean Construction has in the last 10 years become a worldwide concept. This is verified by the establishment of the International Group for Lean Construction, the European Group for Lean Construction, and many national sister organizations. A non-complete list of countries where Lean Construction is adopted in industry is: USA, UK, Finland, Denmark, Norway, Singapore, Korea, Australia, Brazil, Chile and Peru (Ballard and Howell, 2003). Other reports inform that the take up in some countries has been slow, e.g. Netherlands and Germany (Johansen and Walter, 2007, Common *et al.*, 2000). There are for sure several other countries with rising take up of Lean Construction.

There exists several reports point out different barriers for implementation of Lean Construction. Some of the often mentioned barriers are: Deep resistance to decentralized decision making as proposed by the LPS system (Garnett *et al.*, 1998, Johansen and Walter, 2007). Cultural barriers in general is mentioned in several studies (Alarcón *et al.*, 2002, Alarcón and Diethelm, 2001, Johansen *et al.*, 2004, Johansen and Porter, 2003).

5.2 Lean Construction integration in Engineering Education

Not many reports have looked into how well Lean Construction is integrated in engineering education. It is though clear that there is a “competition” of which domains to teach in at universities. Hyatt (2011) concludes that Lean Construction has the least amount of focus within construction management programs. Johnson and Gunderson (2009) have investigated how well recent AEC trends are taken up in engineering education in the US. They found that only half of the US construction management programs include Lean Construction in curriculum. Compared to this research on Danish conditions, the results is very similar. From debates on CNBR forum it is known that some universities in USA, Germany, Israel, Spain and UK have dedicated courses on Lean Construction. In general the tendency is that Lean Construction is placed as a part of construction management course, which limits learning to introduction to Lean Construction.

Another challenge is that since current implementation progress is week, a limited amount of valid course material is available within the market place. Integration problems of Lean Construction in education are hence threefold. 1) Competition with other traditional and new construction management disciplines. 2) Limited amount of course material is available 3) Industry implementation and request for Lean Construction is lagging.

6. Conclusion

Lean Construction education is lagging the construction industry’s development and request for lean knowledge. This so for Danish conditions. In an international perspective the trends seem coherent. The application of lean construction in practice reflects that engineering students mainly only receives an introduction to Lean Construction, and especially Last Planner System.

It is advised to increase the research effort in this area in the future. If Lean Construction should fulfil its potential for increased value and productivity, more knowledge needs to transfer to the industry.

This effort should take place in the ordinary education system and not only as worksite learning in after educations. A global agenda on Lean Construction integration in education is proposed appointed, in e.g. International Group for Lean Construction, Associated Schools of Construction or CIB working commissions on engineering education.

7. Acknowledgement

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A Current View of Construction Management Programs in Higher Education

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Abstract

This research takes a look at the current state of construction management programs in the United States. This research includes a thorough study of the institutions which are providers of construction management education. Included within this study are numerous demographic figures about each school, their curricula, their faculty and facilities, and other relevant information. Most academics involved in this field believe that the way we educate will drastically change in the near future. The information gathered in this study can be used to survey our current condition and to benchmark our future progress. The data used consists of a combination of existing data and data gathered from surveys. The information reveals common trends and issues within our discipline and should be used to make improvements in the future.

Keywords: Education, Facilities, Faculty, Students, Demographics

1. Introduction

Last April, the CIB Commission Workgroup WO89 – Education in the Built Environment, met at the Associated Schools of Construction annual conference. There, they commissioned two studies to compile demographics and descriptive data on construction management education in the United States and the United Kingdom. The aim of the studies is to produce a document that would be used by construction academies throughout the world as a baseline measure of construction education as it exists today and further to plan for the future of construction education.

The goal of this paper is to provide a preliminary look at the United States portion of the study. It is acknowledged that many of the facts and figures which are going to be represented are in some cases derived from a limited number of respondents. The primary source for most of the data contained herein was obtained through the Associated Schools of Construction hereinafter "ASC." In addition, the authors of this paper sent out a supplemental survey to allow the department heads of ASC member schools to fill in information that wasn't provided in their existing data set.

The ASC is recognized as the central hub for all colleges and universities which are involved in construction management education. As stated on its website, the ASC is a "professional association dedicated to the development and enhancement of construction education." The ASC was formed in 1965 by a small number of universities in the United States. The charter members of the ASC conspired to shape the future of construction education. In its inception, the ASC also sought to establish professional recognition for construction education amongst its peer disciplines of architecture and engineering. The ASC was started by representatives from nine universities around the U.S., currently the ASC counts well over one hundred member schools. The expansion of the ASC has benefitted construction education and has advanced its initial goal of bringing professional recognition to our discipline.

The ASC interacts with its member schools by hosting yearly meetings in which it promotes research dissemination of topics including construction education and construction practice. The ASC also engages Universities and their students in regional and national competitions which test core competencies that are taught in each program. In North America, if one were to look for the hub of construction education it would be the ASC. Accrediting bodies differ amongst different schools, and thus, don't make reliable organizations to facilitate a demographic survey.

2. Data Collection

Due to the nature of what the ASC represents for schools of construction management in North America, the ASC is the best place to collect comprehensive demographic data on those schools. From the information that is available on its website the ASC began collecting demographic information from peer schools of construction education as early as 2001. The ASC encourages its members to update their information regularly, and the compliance of its member schools varies. Some of the information contained in the ASC survey is more current then other information. ASC has implemented two surveys, one which includes basic demographic information about it member school's curriculum, students and faculty, and another survey which is strictly concerned with faculty salaries. Both of the surveys developed and maintained by the ASC contain a significant amount of information which forms the backbone of this paper.

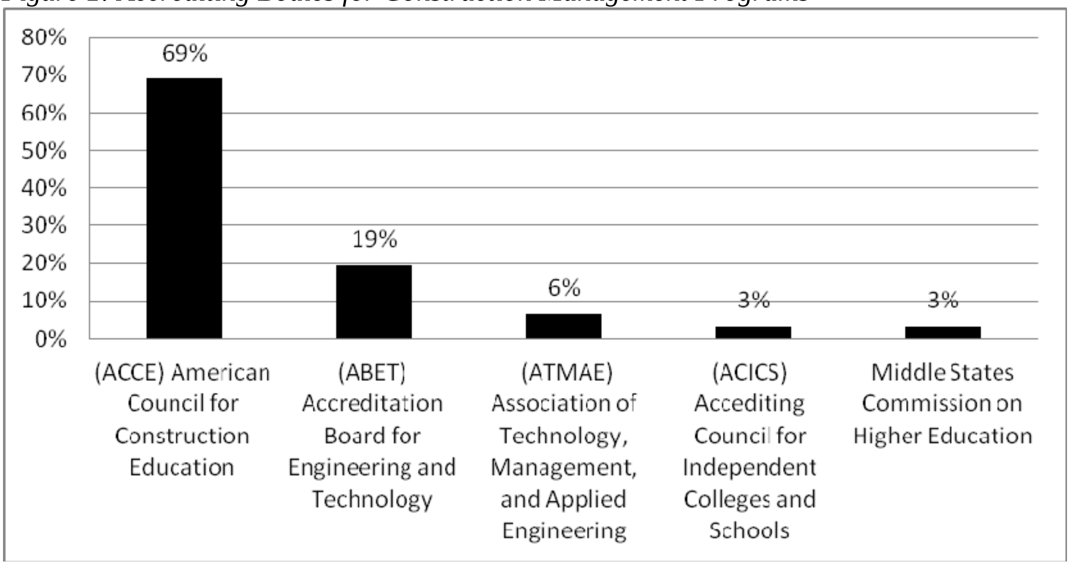
Some demographic information was not provided in the ASC surveys, so the researchers sought to perform their own survey to supplement the existing data. The researchers created a supplemental survey and sent it out to the heads of all ASC member schools. The heads of ASC member schools were chosen so that responses would be limited to one response per school. Out of the 133 ASC member schools only 22 heads responded to the supplemental survey. The original ASC surveys had a much higher response rate in that 101 member schools provided at least a partial response.

3. Data / Analysis

In order to present this voluminous data in a concise a manner as possible the data has been separated into four main categories: 1) Curricula\Administration; 2) Students; 3) Faculty & Staff; and 4) Facilities.

3.1 Curricula \ Administration

Figure 1: Accrediting Bodies for Construction Management Programs



As is seen in *Figure 1* among the surveyed construction management programs 5 different accrediting bodies are represented. The large majority of construction management programs receive their accreditation through ACCE. Construction management programs that are paired with engineering colleges typically receive their accreditation through ABET. The other three accrediting bodies are not widely utilized by construction management programs.

Figure 2: Entry Requirements for Undergraduates

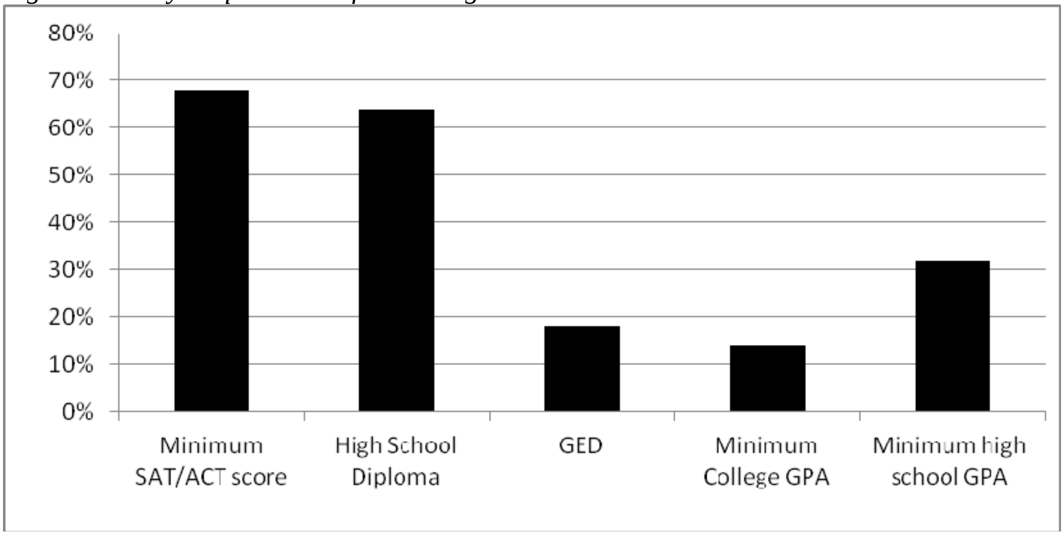


Figure 3: Credentials offered as part of Program

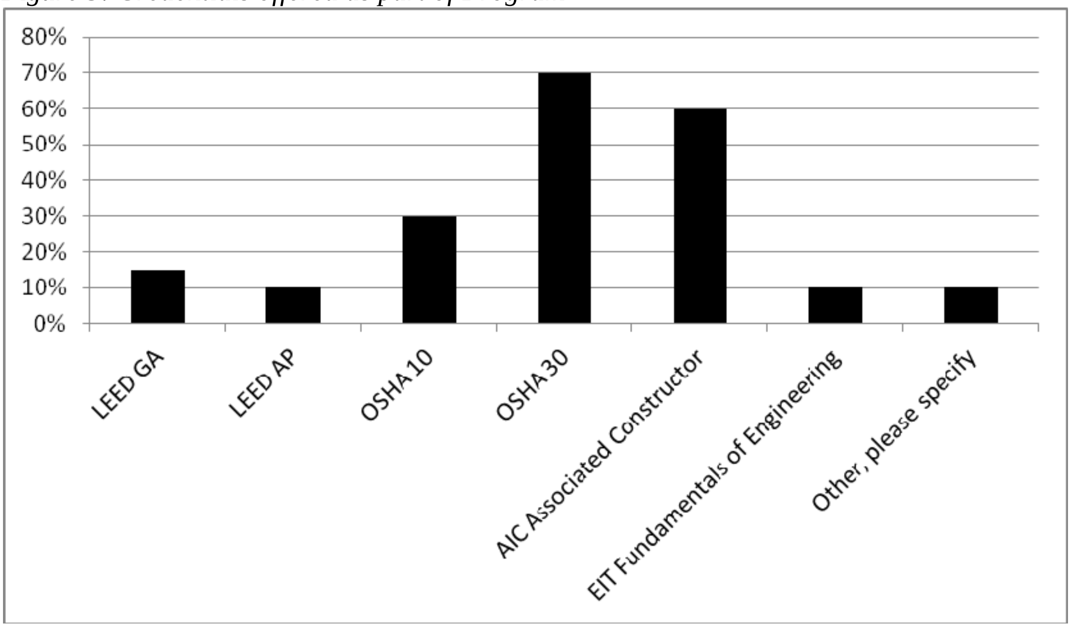


Table 2: Special Programs (Degree Tracks) & Study Abroad

	Special Programs(Degree Tracks)	*Study Abroad*
Yes	*13% (Residential, Heavy Highway)*	*52%*
No	*87%*	*48%*

As seen in *Figure 2*, the entry requirements for construction management schools varies. The respondents identified a number of different metrics which were used for entrants. An element that is not captured in this figure is at what point the students are admitted to the respective programs. Some respondent institutions may admit students as incoming freshman, others might admit after some core competencies have been completed at the university level and then competitively select from a pool of candidates. *Figure 3* reflects the different credentials that are offered through construction management programs and their frequency of occurrence. Most of these credentials are offered for the professional development of the students. Degree tracks are offered by some programs to provide students with an expertise in a certain area within the construction industry. As seen in *Table 2* the majority of programs do not have specialty tracks, but a few exist including residential and heavy highway. Also recorded in *Table 2* is the percentage of schools offering a study abroad experience, the majority of schools seem to offer a study abroad program.

Figure 4: Current Issues Negatively Impacting Construction Management Education

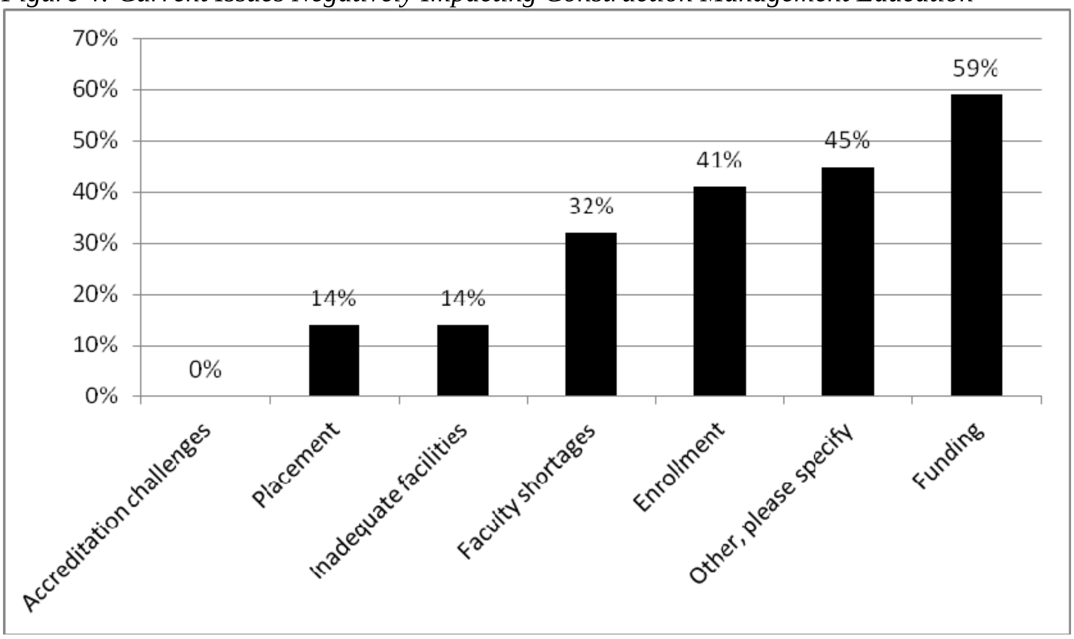


Figure 5: Enrolment Changes over the past 3 years

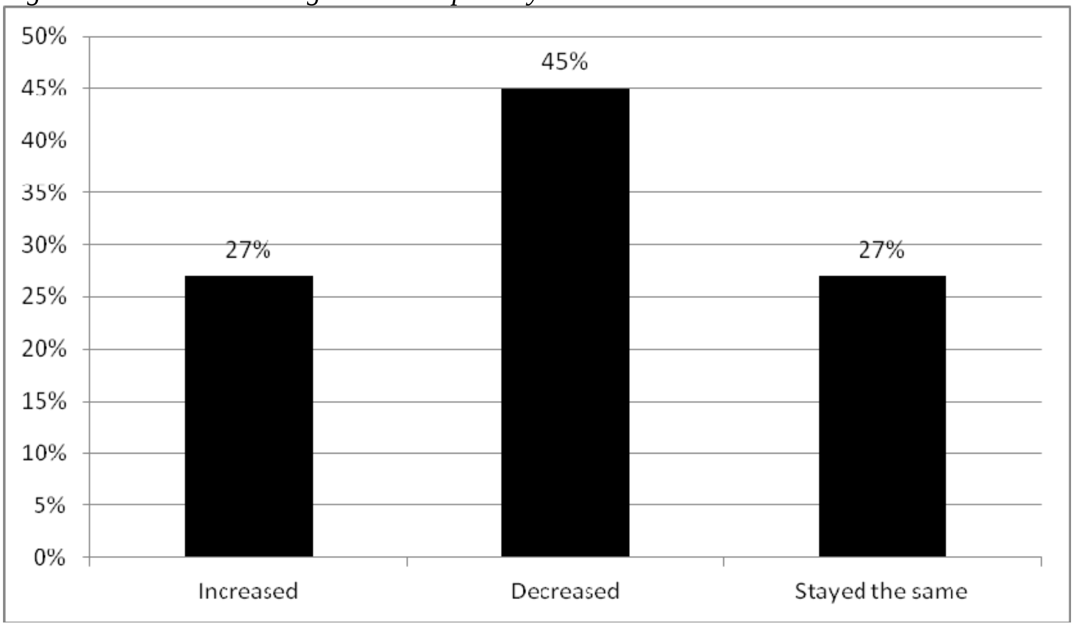
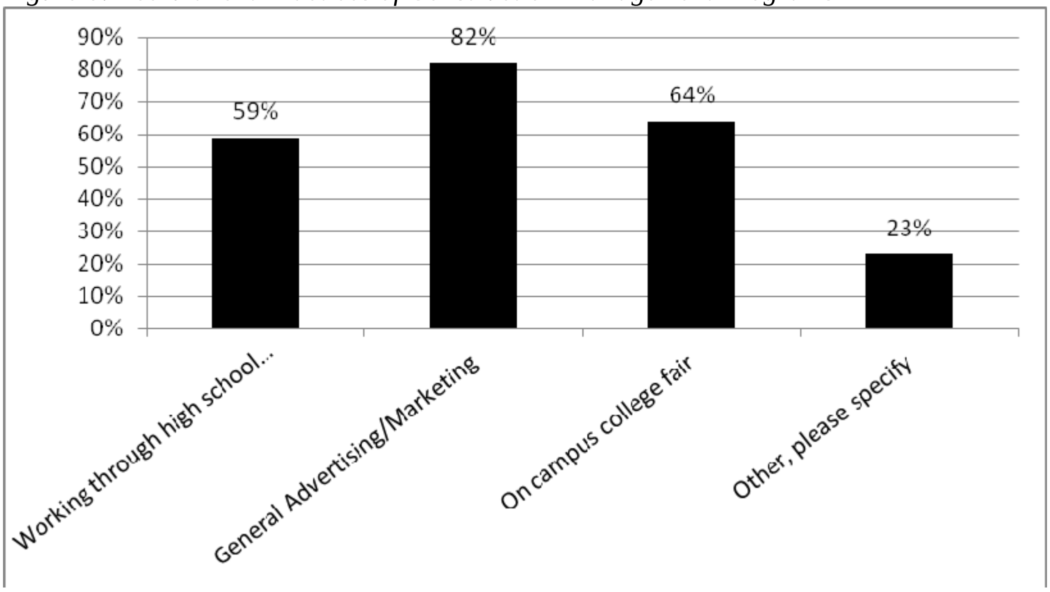


Figure 6: Recruitment Practices of Construction Management Programs



Construction management programs are not without challenges. *Figure 4* shows some of the current challenges facing the discipline. In addition to those included in *Figure 4* respondents were allowed to specify others which included: 1) Administrators that don't understand construction; 2) Perception that the job market is not good; 3) Faculty work load; and 4) Burdensome general education requirements.

Enrolment has become an issue for a significant portion of schools with construction management programs. In *Figure 5* enrolment is decreasing in 45% of schools. This fact is paired with *Figure 6* in that some schools in our discipline traditionally have not had to recruit but now it is becoming a critical tool. Some of the efforts that have been undertaken are detailed in *Figure 6*, and others that were specifically identified include: 1) Common first year with architecture, industrial design; 2) Outreach events with AGC; and 3) Community college transfers.

3.2 Students

Table 2: Undergraduate Programs

	Class Size	*Undergraduates Students*	*Graduating Seniors Per Year*
Average	*27*	*273*	*47*
Median	*25*	*200*	*40*

Table 3: Graduate Programs

	Masters Students	*Graduating Masters Students Per Year*	*Doctoral Students*	*Graduating Doctoral Students Per Year*
Average	*48*	*19*	*14*	*7*
Median	*20*	*8*	*5*	*2*

In *Tables 2 and 3* we see some basic facts and figures regarding the undergraduate and graduate programs of construction management schools. *Table 2* gives some statistics related to undergraduate programs, and reports a typical class size is around 25 and over 200 undergraduate students in the program. *Table 3* provides information related to the graduate programs it shows a median of around 20 masters students and 5 doctoral students per institution. The statistics related to graduate programs reflect averages and medians from only those institutions that reported having such programs.

Table 4: Gender of Students

	Male	*Female*
Average	*89%*	*9%*
Median	*90%*	*10%*

Figure7: Diversity of Student Population in Construction Management Programs

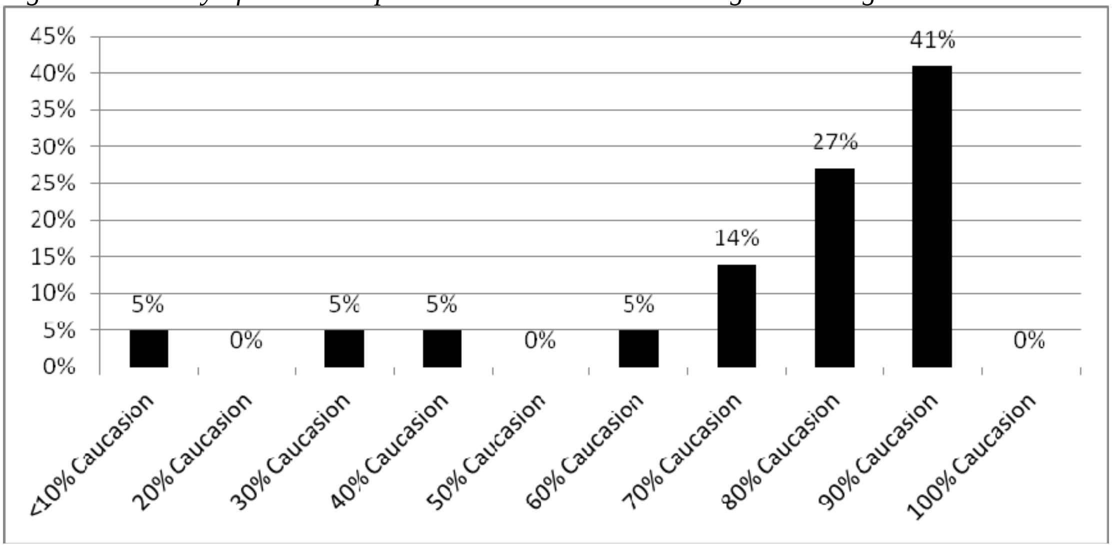


Figure 7.1: Diversity of Student Population in Undergraduate Programs

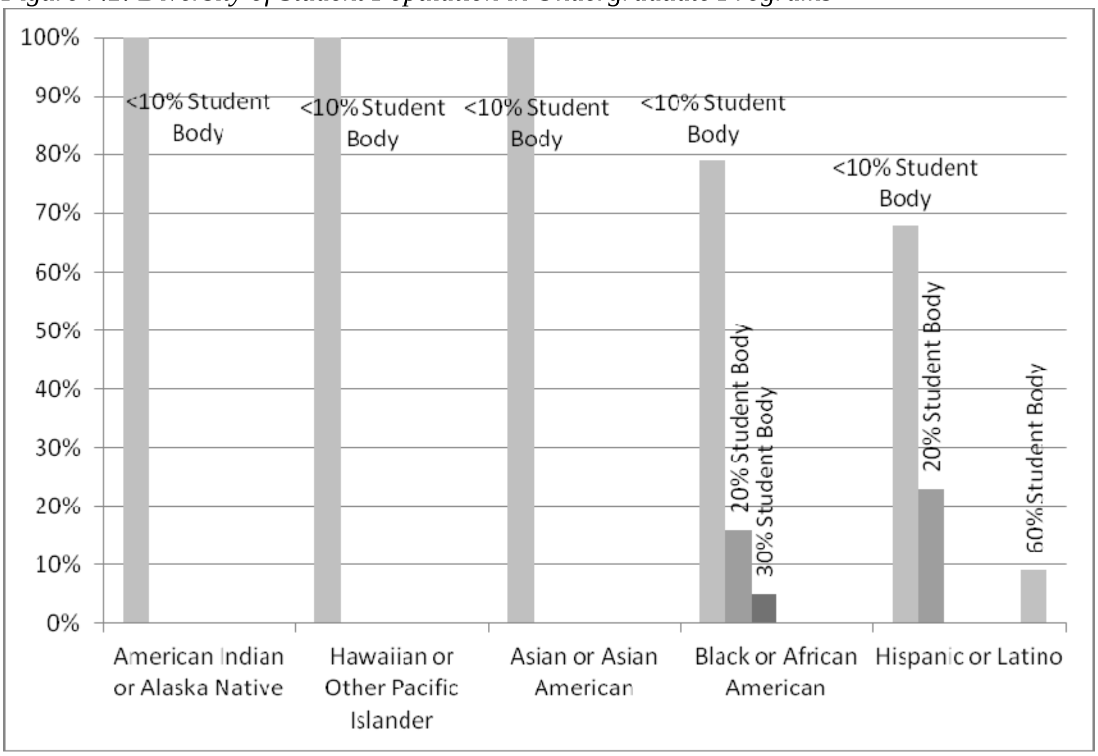


Table 4 and Figures 7 and 7.1 give some facts on gender and racial diversity amongst construction management programs. Gender diversity has been a historical struggle for construction management programs and it continues to be. Racial diversity has also been a challenge for construction management programs and that trend also continues. As seen in *Figure 6* for the large majority (68%) of schools over 80% of the student population is Caucasian. As seen in *Figure 6.1* of the minorities present for most schools they represent less than 10% of the student population. A couple of schools which responded to this survey noted significant African American and Latino student populations.

3.3 Faculty & Staff

Table 5: Faculty

	Full-Time Faculty	*Part-Time Faculty*	*PHD Required?*
Average	*7*	*5*	*Yes (69%)*
Median	*5*	*2*	*No (31%)*

Table 6: Administrative Staff for Construction Management Programs

	Administrative Staff
Average	*2*
Median	*1*

Table 5 and Table 6 provide some information regarding the faculty and staffs which serve the construction management programs. As seen in *Table 5* it appears that institutions generally use a combination of full time and part time faculty and those faculty members are by in large required to have a PHD. In *Table 6* it also appears some schools have administrative staff to serve the department, these positions may include: placement coordinators; financial personnel; student's services; and general clerical positions.

Table 7: Faculty Salaries

	Annual Contract Salary	*Respondents*
Lecturer	*$45,220*	*4*
Assistant Professor	*$67,775*	*12*
Associate Professor	*$74,524*	*11*
Full Professor	*$77,132*	*14*
Department Head / Chair	*$85,981*	*4*

Table 7 provides some information regarding the faculty salaries. The salaries reported are base incomes and generally do not include summer sessions, named professorships or other sources of income common in academia. The faculty salaries reflect an incremental spread from lecturer to department heads.

3.4 Facilities

Figure 8: Age of Facilities

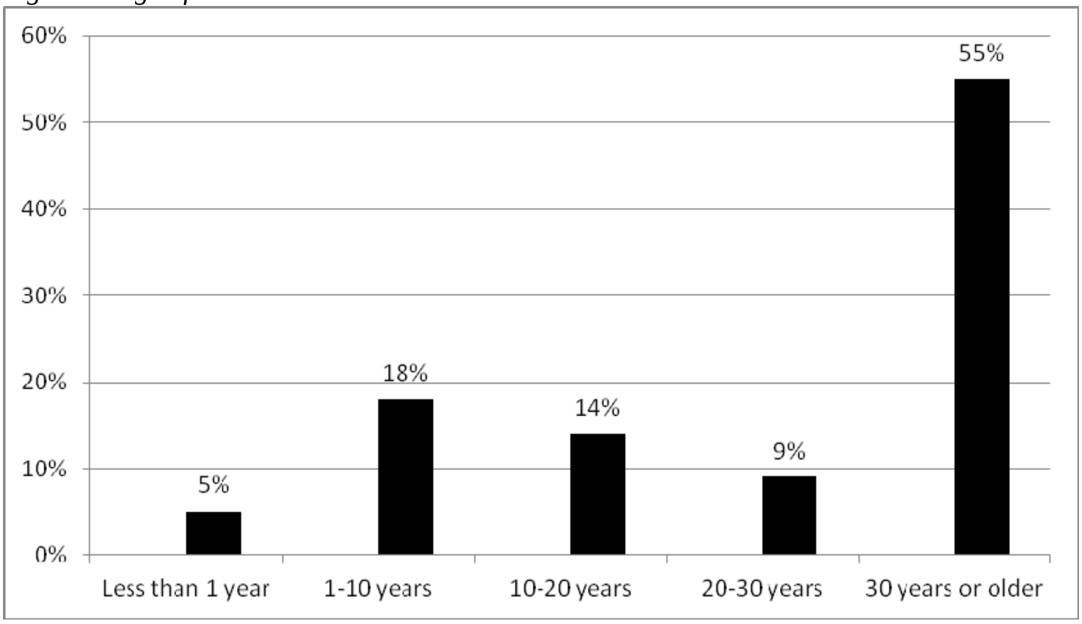


Table 8: Major Renovations / Dedicated Facilities

	Major Renovation within last 10 Years	*Shared Facility with other Academic Units*
Yes	*50%*	*95%*
No	*50%*	*5%*

Table 9: Space Allocations

	Classroom Space (SF)	*Laboratory Space (SF)*
Average	*9684*	*9445*
Median	*5000*	*6100*

Figure 8 and Table 8 and 9 provide some information regarding the facilities that house construction management programs. As stated in Figure 7 the majority of facilities (55%) are in excess of 30 years old. Table 8 states that about half of the facilities have undergone a major renovation within the past 10 years and further that 95% of the facilities are shared with other academic units. Table 9 takes a look at the space allocation for facilities that house the construction management students.

4. Concluding Remarks

This paper provides a look at construction management programs within the United States. One thing is clear that as a discipline in higher education construction management programs have become widely recognized and added to their professional credibility over the years. In the course of this research it has become apparent that a primary reason for this broader acceptance is that the number of institutions offering construction management programs has increased as compared to years past.

Challenges exist for most construction management programs. Some of these challenges are not new and have been persistent through the years including funding, student diversity and older facilities. These challenges have persisted and continue to present opportunities for significant improvement. In addition to these historic challenges some new and unexpected challenges have arisen recently including enrollment, recruitment and job placement. The years prior to 2008 were profitable for most of the construction sector and fueled high job placement for our graduates. The recent recession resulted in a significant slow-down in the construction sector and had immediate impacts on our graduates' employment potential. It is believed by many that this fact has reduced enrollment levels as perspective students have become aware of our recent graduates difficulties in obtaining employment and fear that it will affect them as well. It is anticipated as the economy improves the construction sector will improve which will in turn benefit construction education as students return to recognize our discipline as a stable career path.

The data for this research was collected from construction management programs in the United States, but many of the challenges identified above were not just regional issues and had a global reach, specifically the recent economic slow-down. It is thought that construction management education worldwide suffers from similar challenges and could benefit from similar solutions. It is hoped that the information contained in this paper will be used by institutions as a baseline and also lead to solutions for some of the problems we are facing.

5. Reference

Associated Schools of Construction (2012) *University Demographics Survey and Salary Survey*, available: http://ascweb.org/membersOnly/index.php [accessed in March 2012].

Setting Global Academic Standards for the Building and Construction Industry: A Discussion Piece

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Abstract

Building and construction industry professionals are competent to practice because of the knowledge, skills and attitudes they have developed over the course of their education, training and work experience. Different professional groups, registration boards, companies and construction organisations in different jurisdictions can have quite disparate expectations of how professional competence should be constituted and how it might usefully be measured. With the globalisation of the construction industry and increasing mobility of labour it is timely to review how academic standards for building and construction professions should be benchmarked internationally.

This paper will review some of the global trends in academic standards generally, and compare and contrast more specifically the current developments in academic standards for building and construction in Australia, the UK and USA. The case will be made for setting academic standards for building and construction practitioners globally.

A variety of models for and approaches to setting global academic standards will be considered and discussed. The paper concludes with a proposed agenda for setting global academic standards in the building and construction industry.

Keywords: Academic standards, Benchmarking, Globalisation, Building and construction

1. Introduction

Significant developments are taking place internationally that relate to both the policy and practice of building and construction education. Those developments have implications at the micro and macro levels of higher education. They flow directly to and from the broader context of professional practice. Critically, these developments are being fragmented across national and professional borders. The opportunity exists for current global change to result in a more coherent and harmonious educational framework for building and construction.

It is useful in the current context to consider building and construction education as a single, important step on the pathway to professional practice. Figure 1 illustrates this notion of the pathway to professional practice as a series of steps. Taking building and construction education as the first step, this leads to a period of post-education training and industry experience, and only then leads to authentic professional practice. Progression from one step to the next is generally controlled through some form of assessment regime that ensures candidates have achieved the requisite standard to progress. The quality of those standards is assured at each step through a variety of conventions and systems.

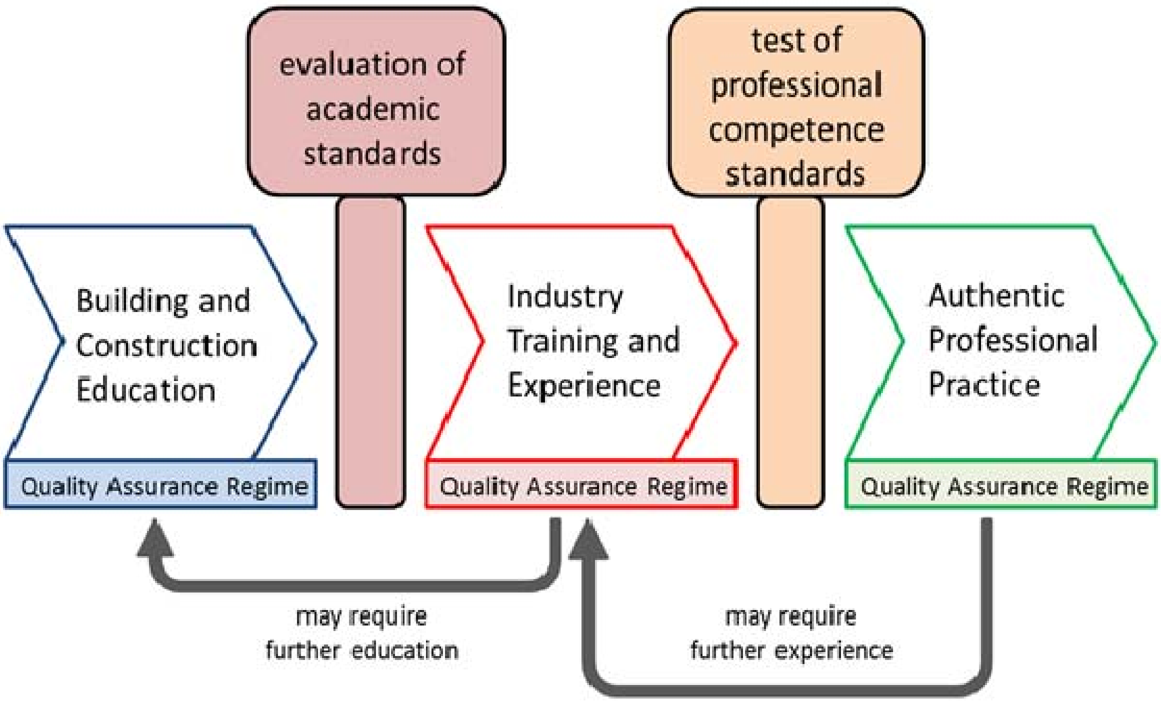

Figure 1: The pathway and Steps to Authentic Professional Practice

The quality assurance regime for building and construction education is achieved by mapping course outcomes to specific academic standards, aligning assessment tasks with course objectives, using appropriate learning and teaching strategies, maintaining provider standards, etc. The academic standards of building and construction education are then most typically evaluated by some external accreditation agency. The quality assurance regime for industry-based training and experience is achieved by effective mentoring and supervision, broad exposure to and engagement with industry practices, structured training programs, etc. The professional competence of individual candidates is formally assessed by an appropriate professional body and specific test of professional competence. The quality assurance regime for professional practice is then assured by adhering to codes of conduct, continuing professional development, industry standards, effective human resource management, etc. At each step, a return to some previous step may be required.

It is also worth noting that Figure 1 is an idealised representation of the typical pathway. There is growing integration of industry training and experience into building and construction education. There is growing supplementation of industry training and experience with in-house building and construction (continuing) education. Whilst professional accreditation is not always the same as academic standards for learning and teaching clearly the two are intimately related. The difference is most often in terms of the underlying purpose. In the case of academic quality assurance, there is a focus on student learning outcomes that culminate in the award of an academic qualification. For professional accreditation, there is a focus on student learning outcomes in relation to the requirements for safe and competent professional practice. In building and construction, it is also the case that professional accreditation is not a prerequisite to authentic professional practice.

Building and construction industry professionals are competent to practice because of the knowledge, skills and attitudes they have developed over the course of their education, training and work experience. Different professional groups, registration boards, companies and construction organisations in different jurisdictions can have quite disparate expectations of how professional competence should be constituted and how it might usefully be measured. With the globalisation of the construction industry and increasing mobility of labour it is timely to review how academic standards for building and construction professions might usefully be benchmarked internationally. This paper is concerned with the academic standards of building and construction education: what the standards are, how they get accredited and how they should be benchmarked internationally.

2. Academic Standards

The term ‘academic standards’ is used in a variety of ways, and is often ambiguous (Yorke, 1999). Its definition has been explored in several recent reviews (see for example, Coates, 2010; Harris, 2009). Several key distinctions should be drawn:

(i) Provider standards versus program standards – the institutional standards of service provision, quality assurance protocols, resourcing and so forth, compared to the learning outcomes from particular programs of study. This paper concerns program standards.

(ii) Qualification standards versus discipline standards – the generic regulatory frameworks that stipulate the volume of learning, purpose of the award, broad capabilities, etc. for the different levels of learning awards (from school-leaving certificates through to PhD), compared to the standards specific to a particular level of award made particular to a given discipline (such as building and construction). This paper concerns discipline standards.

(iii) Aspirational standards versus baseline standards – the standards set as goals towards which programs of study will develop, compared to the standards that all programs of study in a particular jurisdiction will be guaranteed to have achieved. This paper concerns baseline standards.

(iv) Content standards versus performance standards – the specification of program content in terms of subjects taught and knowledge delivered, compared with the evaluation of student capabilities and learning outcomes. This paper seeks to move the consideration from (input) content standards to (output) performance standards.

(v) Formative standards versus summative standards – the staging of learning development within the term of a particular program of study, compared with the staging of learning development at key points on the pathway to professional practice. This paper is concerned with summative standards at the transition point from building and construction education to post-education training and industry experience. That point is typically at graduation from a baccalaureate degree program.

The attention given to academic standards has grown significantly over recent years for a number of reasons:

(i) A broad recognition internationally that "the reach, quality and performance of a nation's higher education system will be key determinants of its economic and social progress" (Bradley, 2008: xi). This has promoted a series of national reviews of higher education, including in the UK (Dearing, 1997) and Australia (Bradley, 2008). A critical issue in all of these reviews has been the quality assurance of graduate outcomes, typically expressed in terms of academic standards.

(ii) The Bologna Declaration of June 1999 has put in motion a series of reforms, first in Europe but later in other jurisdictions, to help make higher education more compatible and comparable, within and across national borders (EACEA P9 Eurydice, 2010). The transparency and consistency of how academic standards are measured and reported is a fundamental platform of the Bologna initiative.

(iii) A more active engagement with and involvement in higher education practice by the relevant professional bodies. Professional bodies have sought to clarify and review their professional pathways, including giving particular attention to the accreditation of building and construction education programs. See for example, CIOB (2007) and RICS (2008). This drive by professional bodies to exert more specific influence on building and construction education has brought the question of academic standards into greater relief.

(iv) The currency and popularity of constructivist and experiential theories of learning has had direct impact on pedagogy and educational reform (Piaget et al, 2001). In particular, it has promoted the teacher as a facilitator of learning and rendered added emphasis to student-centred approaches. Placing the student centre-stage in this way results in measures and criteria for learning that articulate around the learning achievements (outcomes) of each individual student.

A recent review of international trends in the development of academic standards specific to higher education identified five separate focal points for the consideration of academic standards related to learning outcomes (Harris, 2009). Figure 2 represents the conceptual framework emerging from that review, with the five focal points marked A through E. Points A to C each relate to setting expectations. D and E represent distinct approaches to the measurement of attainment.

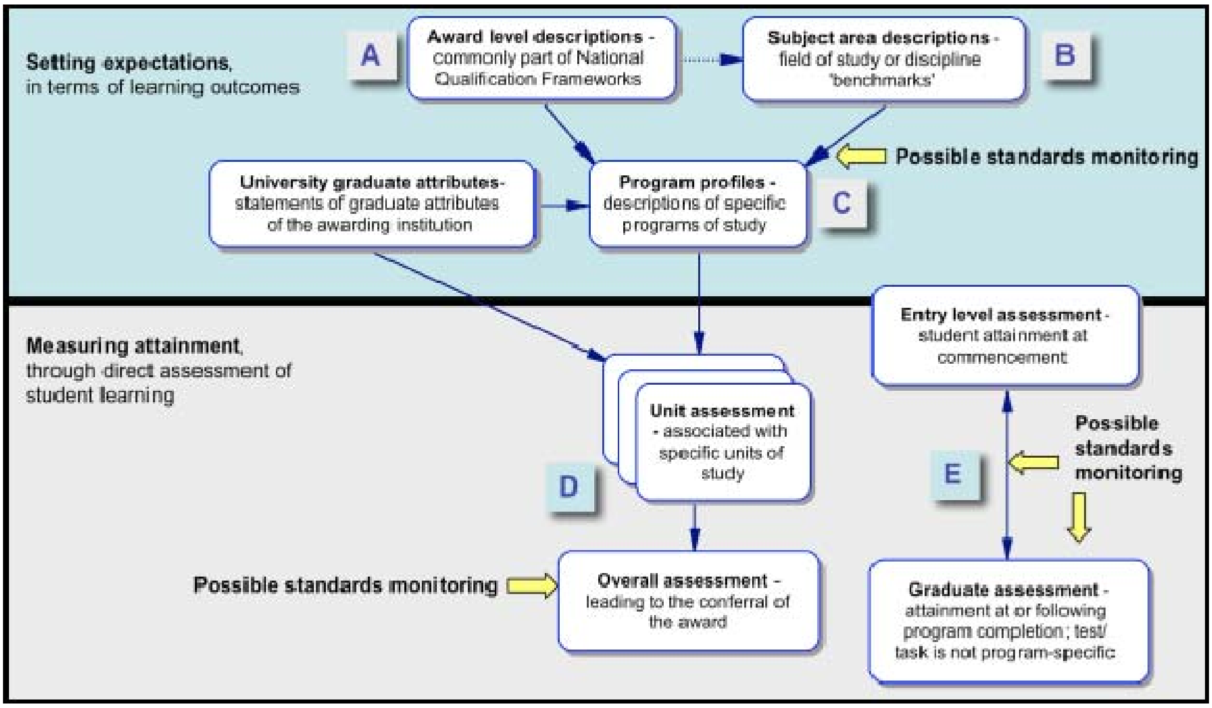

Figure 2: A Conceptual Framework for Setting Expectations and Measuring Academic Achievement (Harris, 2009: 2)

Point A (Award level descriptions) would include such initiatives as the Dublin Descriptors, defining learning outcomes in simple generic terms for broad application (available at: http://www.jointquality.nl/ge_descriptors.html). Typical terms include knowledge and understanding, applying knowledge and understanding, making judgements, communication, and learning skills. Point B (Subject area descriptions) would include such initiatives as The Tuning Process, which seeks to identify threshold-level learning outcomes for a wide range of subject areas, but particular to each discipline group (Tuning, 2010). Point C (Program profiles) would include such initiatives as the CoRe Project which seeks to identify learning outcomes specific to particular programs of study (available at: http://www.core-project.eu/?file=core1/background). Point D (Program-specific assessment) would include a broad range of initiatives, such as the external examination system of the UK, which seeks to determine whether a candidate has met or exceeded the threshold requirements for a particular award based on the actual assessment tasks completed (QAA, 2009). Point E (External graduate assessment), possibly the most contentious, would include such initiatives as the AHELO project, which provide for a common, broad-based external method of measuring student attainment (OECD, 2009).

Together these five focal points identify the full range of issues to be considered relative to academic standards. This paper will consider only Point B initiatives, as initiatives at that level best accord with consideration of the building and construction discipline. It is recognised that much work has already been completed around the other points of focus, and that such developments will have implications for Point B. However, a review of the entire framework would be monumental and given that much work remains, probably premature.

3. Building and Construction Subject Area Descriptions

Subject area descriptions are perhaps best considered as benchmarking exercises for a particular field of study or discipline group. Building and Construction would represent such a field of study/discipline group, and be distinguished from the other fields of study that comprise the modern academy, such as Architecture, Engineering, Law, etc. This is not a clear boundary of course. The discipline of Building and Construction draws together a substantial range of otherwise distinctive communities of academic and professional practice, around a rich and dynamic mix of project activities. At the core of the discipline are a number of discrete professions such as Construction Management, Quantity Surveying, Building Surveying, Facilities Management and Property Development, united through a shared concern with the initiation, provision, operation and sustainability of the built environment. The broad nature and extent of Building and Construction can involve projects that vary in scale and complexity from a minor home renovation through to national-level infrastructure developments, with all levels of domestic, commercial and industrial activities in between.

With internal professional boundaries in a state of flux and the structure of the industry shifting, no clear definition of the discipline is likely to be agreed to by all stakeholders. There are further complications with the articulation of boundaries between Building and Construction and its allied disciplines such as Architecture, Civil Engineering, Business and Law. In key jurisdictions Construction Management is accredited as both a Building and an Engineering professional pathway.

Broadly speaking, however, Building and Construction work includes activities such as planning, commissioning, design, construction, alteration, repair, operation and demolition of any structure that forms a permanent or temporary part of the environment. It is a highly significant market sector of any modern economy, competitive and innovative. Most notably perhaps, it is very much a project-based industry. Any degree program in Building and Construction will therefore require students to study the science and technologies of multiple and varied forms of construction, the management of projects and people, market economics and finance, as well as the laws of business, contract and real property. As a consequence, Building and Construction programs of study draw upon knowledge, concepts and paradigms from a wide range of academic sources and a Building and Construction graduate has the potential to pursue a host of divergent and emerging careers, both nationally and internationally.

Building and Construction professions operate as part of a multi-disciplinary team, often taking a leadership role. They are required to communicate formally and informally with the complete spectrum of stakeholders, from clients to subcontractors, from lay public to technical specialists, and from tradespeople to regulators. The project-by-project focus demands mental agility and analytical problem-solving capabilities that deliver specified building performance outcomes. Most critically, Building and Construction is a vocation. Practical experience is an essential element of any Building and Construction professional development. Fashioning the most effective relationship between academic and practical experience (their integration and balance), is perhaps the key challenge facing the discipline at this time.

Given that broad definition, what initiatives around academic standards for building and construction at the subject area level of description are current in different jurisdictions?

3.1 Australia

The Australian Government recently established the Tertiary Education Quality and Standards Agency (TEQSA) as a national body for the regulation and quality assurance of tertiary education against agreed standards. In 2010, the Learning and Teaching Academic Standards project commissioned 10 broad discipline groups to determine the Threshold Learning Outcomes (TLOs) appropriate to their discipline at a particular level of award (ALTC, 2009). Taken as a whole, the TLOs represent what a graduate is "expected to know, understand and be able to do as a result of learning" (AQF, 2010).

The TLOs for Building and Construction were developed through extensive consultation and engagement with the key discipline stakeholder groups. The consultation included all higher education providers of Building and Construction degrees in Australia, all relevant professional accreditation bodies (local and international), key industry professionals (representing small, medium and large organisational settings and a broad sample of industry sectors), key academic leaders, current students and recent graduates (Newton and Goldsmith, 2011). Each of the resulting TLOs is defined independently, but it is recognised that there are inevitable overlaps when graduates come to demonstrate each as part of a coherent assimilation of knowledge, skills and capabilities.

The TLOs are expressed as the baseline for graduation. All providers of a Bachelor-level degree program that promotes its graduates into the Building and Construction discipline would be expected to provide explicit evidence that they meet or exceed these standards at the time of graduation. Program diversity is valued and it is presumed that each relevant program of study will develop these and other learning outcomes beyond the baseline to a different extent, perhaps to reflect and distinguish their particular graduate profile from those of other providers.

The TLOs are expressed under six broad themes and each is structured to include one or more action verbs (what the graduate must be able to do), the level of achievement (how well they must be able to do it) and scope (in which context setting). The TLOs specified for graduates upon completion of any of a bachelor degree in Building and Construction in Australia are (Newton, 2011: 9):

- Integrate and evaluate the fundamental principles and technical knowledge of building and construction technology, management, economics and law.
- Identify and resolve typical building challenges with limited guidance, employing appropriate evidence-based problem-solving and decision-making methodologies.
- Critically and creatively reflect on personal behaviours and capabilities in the context of entry to professional practice.
- Interpret and negotiate building and construction information, instructions and ideas with various project stakeholders.
- Research and develop methods and strategies for the procurement and delivery of contemporary construction work.
- Demonstrate an integrated understanding of both the theory and practice of building and construction based on experience.

3.2 United Kingdom

The Quality Assurance Agency for Higher Education (QAA) published the first subject benchmark statement for Building and Construction (more specifically Building and Surveying) in the UK in 2002. This statement was reviewed and updated in 2008 as the benchmark statement for Construction, Property and Surveying (QAA, 2008).

Subject benchmark statements are developed by the relevant academic community. They establish the general expectations of the attributes and capabilities a graduate with a single honours degree within the subject of construction, property and surveying should have demonstrated. In addition to general expectations, subject-specific and generic skills are also identified. For Construction, Property and Surveying these skills are specified at two levels, namely threshold and typical. “The threshold standard describes the minimum level of attainment for the award of a single honours degree; the typical standard describes that achieved by the majority of graduates” (QAA, 2008: 8).

Threshold skills:

- Recognise the nature of the relevant specific discipline and its relationships within the context of the subject
- Describe and apply a range of relevant key concepts, theories and principles
- Identify and recognise relevant issues and why they are important
- Recognise and apply all relevant aspects of management and other specialisms within the context of regulatory requirements, the needs of society and ethical correctness
- Select and apply ICT applications appropriate to the discipline

- Present original ideas and reflections via a range of methods to convey appropriate standards of literacy and the use of numeric data
- Identify and explain the nature of the various working interactions and relationships in a professional context.

Typical skills:

- recognise and anticipate the need for change in the relevant discipline and perceive future trends leading to the formation of informed questions
- describe and examine a range of key concepts and theoretical approaches and evaluate their effective application
- analyse the relative importance of relevant issues and their future application
- evaluate and make judgements about all relevant aspects of management and other specialisms within the context of regulatory requirements, the needs of society and ethical correctness
- select and evaluate ICT applications appropriate to the discipline and evaluate and present original strategies to carry out a particular task
- analyse working relationships and interactions and evaluate their own strengths and weaknesses in a professional context.

3.3 United States of America

In the USA, accreditation in higher education is self-regulated, but requires explicit peer review of academic quality. The Council for Higher Education Accreditation (CHEA) is an association of 3,000 degree-granting colleges and universities and recognizes 60 institutional and programmatic accrediting organisations to accredit academic standards. Bachelor degree programs in Construction Management are accredited by either the American Council for Construction Education (ACCE) or ABET (originally the Accreditation Board for Engineering and Technology, but that title is no longer used).

The terms of an ACCE accreditation are set by prescribing minimum hours of academic credit across six curriculum categories (General Education, Mathematics & Science, Business and Management, Construction Science, Construction and Other). Within each curriculum category there are minimum hours of academic credit requirements for core subject material. In addition, there is a requirement for curriculum to contain a mix of fundamental and topical content. This three level structure of curriculum categories, core subject matter and fundamental topical content was established in 2002, following almost 10 years of committee work. For further details, see: http://www.acce-hq.org/. The ACCE is currently working towards a more learning outcomes-based approach to standards.

The terms of an ABET accreditation range across a variety of criteria (see: http://www.abet.org/criteria-engineering-technology-2012-2013/). The approach requires documented student outcomes that prepare graduates for explicit program educational objectives. For baccalaureate degree programs, the learned capabilities include:

- ability to select and apply the knowledge, techniques, skills, and modern tools of the discipline to broadly-defined engineering technology activities
- ability to select and apply a knowledge of mathematics, science, engineering, and technology to engineering technology problems that require the application of principles and applied procedures or methodologies;
- ability to conduct standard tests and measurements; to conduct, analyze, and interpret experiments; and to apply experimental results to improve processes;
- ability to design systems, components, or processes for broadly-defined engineering technology problems appropriate to program educational objectives;
- ability to function effectively as a member or leader on a technical team;
- ability to identify, analyze, and solve broadly-defined engineering technology problems;
- ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature;
- understanding of the need for and an ability to engage in self-directed continuing professional development;
- understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity;
- knowledge of the impact of engineering technology solutions in a societal and global context; and
- commitment to quality, timeliness, and continuous improvement.

4. Key Discussion Points

(i) Whilst there is much in common, substantive changes in context and conditions across national borders means important differences must be recognised and accommodated. Even within a jurisdiction, multiple accreditation models might apply to the same professional outcome. One-size of academic accreditation will not fit all globally.

(ii) The strong trend by national governments to require academic standards to be expressed in terms of learning outcomes offers real possibility for improved alignment internationally. It removes one of the critical differences between certain jurisdictions.

(iii) Any system of academic accreditation must be flexible and dynamic over time if it is to respond effectively to a rapidly changing context and the specific differences in particular situations.

(iv) Custodianship of the accreditation system is critical. Support appears to be growing for the notion that custodianship should be vested in a community of stakeholders rather than any particular vested interest, such as the providers themselves, governments or individual professional bodies. Unfortunately there is typically no obvious candidate in place to represent the community of Building and Construction stakeholders at a national or international level.

(v) The general lack of registration or licensing of building and construction professionals means there is no obvious alternative for universal quality assurance other than academic standards – the professional test of competence only applies to a proportion of professionals working in the industry.

There is a growing movement towards certification and licensing to regulate Building and Construction professionals, but these tend to remain voluntary as governments continue to resist any form of closed shop.

(vi) Other things being equal, government policies designed to promote broader access to higher education will inevitably place downward pressure on academic standards. Some robust minimum or threshold benchmarking requirement, if effective, would contain the downward pressure.

(vii) Internationalisation of the building and construction industry makes effective alignment of academic standards more vital. Organisations are increasingly multi-national, the industry is global and labour is highly mobile.

(viii) International agreements governing mutual recognition of academic qualifications in engineering (the Washington Accord and others) have helped promote international exchange and strengthened the standing of individual national accreditation processes. They have enhanced the position of the profession compared with other professions and increased mobility of professionals and the engagement of employing companies and education providers with their professional body. For example, the Washington Accord (http://www.washingtonaccord.org/) recognises the substantial equivalency of accredited programs and recommends that graduates of accredited programs from one signatory body be recognized by all other bodies as having met the academic requirements for entry to the practice of engineering in that jurisdiction.

Notwithstanding the other significant issues that arise at the various other points of focus in Figure 2, it is patently clear that even specific to Point B (Subject area descriptions) much is still to be determined before academic standards for building and construction can usefully be set globally. Nevertheless, key imperatives, emerging opportunities and important precedents all suggest that now is the critical moment for discussion and consideration to begin and progress. Some further clarity to, and consensus around, the key discussion points presented in this paper will drive the possibility of global academic standards for building and construction forward significantly.

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Empowering reflective learning with self and peer competency assessment practice

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Abstract

Increasing industry participations among students present significant challenges in successful delivery of education in the professional course such as construction management. Unrealistic students' expectations and easy access to lose information adds further complexity in achieving balancing act between lecturers and students. Reflective learning is considered to be one of the best approaches among the working students in the professional programs. This paper presents a self-learning model that ensures students meeting the learning challenges with their inherent professional and managerial skills. The model applied in delivering a number of project management subjects at the graduate program facilitates self-motivation and self-direction encouraging clear responsiveness in the learning programs. Progressive learning and competency development for effective utilisation of project management knowledge and methodologies have been encapsulated to match the needs of the future. A research-based self and peer assessment framework has been devised to facilitate quantified development and progress within a controlled learning process. This distinct learning mechanism aims to empower students' reflective learning in professional settings whilst referencing to the global competency frameworks from major professional bodies. The outcomes and validity of the pedagogy has been demonstrated using a case study experienced in the class.

Keywords: reflective learning, competency standards, project management

1. Introduction

The continuous development of the multifaceted characteristics of the construction management (CM) and project management (PM) professions has increasingly been a focus of attention over the last few decades. Due to the involvement of a multitude of stakeholders and conflicting demands in modern construction projects, the role of project managers in the job is increasingly becoming complex. In addition to the core responsibilities (such as project controlling, on time and within budget delivery) of the typical project manager’s job, project managers are increasingly drawn upon for managing stakeholders’ expectations throughout the project. Evidently, organisations in many industry sectors are moving away from traditional forms of management towards a more project-oriented culture. In order to perform with such a diverse responsibility, project management education requires to blend with the technical and management skills with soft or inter-personal skills for successful management of projects (Dooley et. al., 2005).

While continuous development in the CM and PM professions is growing over past decades, the relevant educational model with appropriate delivery strategies becomes the point of major concern among the higher education industries (Munns, 2001). Recently, many universities have been trying to adopt distance educational model using online delivery platform. This is mainly due to enhanced flexibility for catering for the increasing number of working students in university education (Manivong and Doloi, 2004). Nunan (1994) asserted that the traditional delivery practices in the classroom environment do not provide sufficient flexibility in terms of time and locations for global audiences (Nunan, 1994). With a similar perspective, Emeritus Professor Wells (1998) asked a critical social question in relation to the increasing tread of flexibility being moulded in the traditional university business: “how are we going to manage higher education, maintain standards, be innovative and serve the students?”. On the other hand, such movement perhaps is well justified with the ever-increasing pressure on university funding where full fee paying students are becoming the core in sustainable university business (Doloi and Stevens, 2004). In order to meeting the increasing cost of education, students are evidently taking up the option of working part-time and studying full-time especially in postgraduate courses. In order to meeting the core educational business of ensuring specific learning outcomes among students, universities must adapt to the innovations providing opportunities, flexibilities but meeting the target of the required competencies across the relevant professional bodies (Davis, 2005).

2. Research Questions and Methodology

Today’s higher education providers are seen to be a more strategic venture where multi-disciplinary dependencies contribute to the fulfilment of strategic objectives of the entire educational systems (Doloi and Manivong, 2004). While the institutions are focusing more and more on the quality outcomes in professional education, increasing industry participations among students presents significant challenges in successful delivery of education in professional courses such as construction and project management. Unrealistic students’ expectations and easy access to loose information adds further complexity in achieving balancing act between lecturers and students. In order to deliver professional education, a balance between both teaching and students' end needs to be achieved so that the progressive development of professional knowledge through the education can be quantified. To this front, reflective learning is considered to be one of the best approaches among the working students in the professional programs (Schon, 1983). This research presents an innovative self-learning model that ensures students meeting the learning challenges with their inherent professional and managerial skills.

Given the profound changes in educational environments and the increasing evidence of the shift of the students' participation and expectations, this research has been developed to address the following key questions:

- How does the increasing demand in today's educational practices impact on empowering the participants in the profession with target learning outcomes?
- How can the professional educational practices remain relevant for the continuous professional development among the diverse participants?
- How can advancement of information technology (IT) and information services (IS) be used for strategic existence of an educational institution?
- Will the IT based framework be seen as a core capability in delivering required competency in project management education and supporting the flexibility, reflectivity and adaptability across the global boundary?
- How will the delivery of knowledge be relevant to ensure diagnostic cross communication between current industry practices and the professional education program?

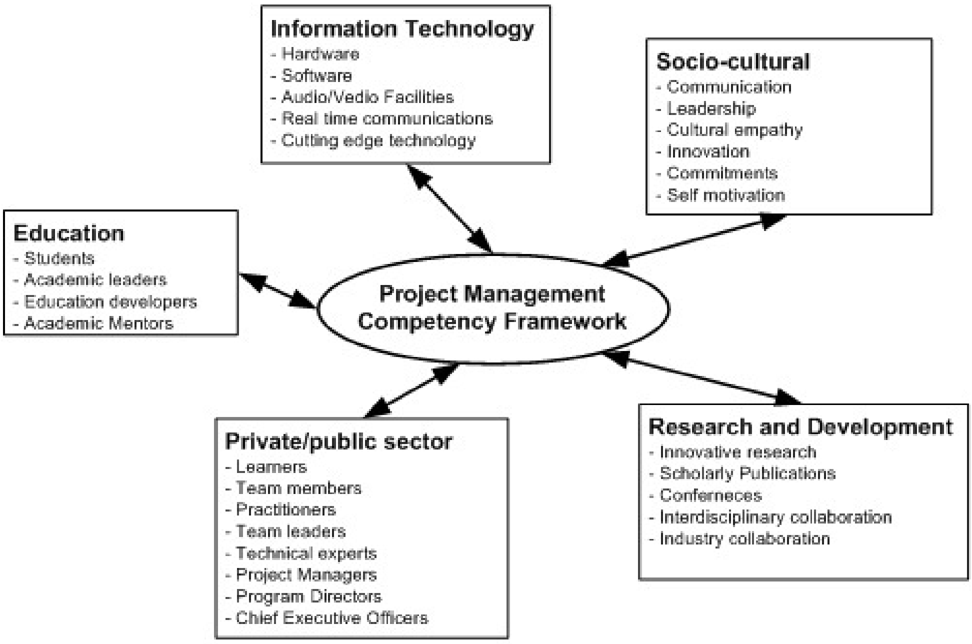
Focusing the above questions, this paper aims to define an advanced reflective delivery framework and underlying strategies in a proactive and explicit manner. The research investigates the robustness of using a learning management platform as a core functionality for designing and delivering the core capability for delivering the professional or industry competency to the target audience in a construction management course at the University of Melbourne. A case study is used to demonstrate how the framework has been used to effectively deliver the knowledge and ensure the appropriate practice-based educational outcomes in a reflective learning environment.

3. Competency based learning and development

An effective learning environment relies on the competencies of those who are going to use such education in practice. Regardless of infrastructure and other associated delivery factors, the competency framework is the key to delivering practical knowledge in the higher education sector (Crawford, 2004; Morris, 2004). Figure 1 shows a high-level competency development framework integrating environments and associated business roles in the project management context.

As seen, the framework comprising practice roles and competencies associated with the educational model requires the curriculum objectives and technological balance effectively. While discussing competency based education, the characteristics associated with the term 'competency' are quite unique. The underlying characteristics are realized mainly among the people and their behaviour or thinking patterns across any situation over a reasonable time period (Manivong and Doloi, 2004). The terms "competency" usually refers to the skills, knowledge, personal characteristics and behaviours needed to effectively perform a role in an organisation in order to contribute to meeting the strategic business objectives.

Figure 1: Competency Development Framework



There is an essential need for educators to clearly understand the related roles and competencies for professionals in applied field (Crawford, 2004). The development of professional education must be able to integrate the roles of key stakeholders or target audiences with their business roles and responsibilities facilitated by the emerging pedagogy and technology. As shown in Figure 1, five major drivers such as Education, *Information Technology*, *Socio Cultural aspect*, *Research and Development* and *Private/Public Sector business practices* have been integrated in developing the competency framework in the model. In competency based learning, progressive reflection is one of the key elements in order to realise appropriate educational outcomes.

3.1 The Reflective Pedagogy

Figure 2 shows the pedagogical model of the reflective learning framework. The model has been developed by integrating the views of a number of stakeholders from the teaching and learning points of view, such as students, tutors, course advisors and course designers.

The overall model has been comprised of three major phases, such as: *design and development* phase; *delivery* phase and *review, reflection and update* phase. The design and development phase focuses on design and staged delivery of the subject-specific technical contents in the professional educational program. In a typical subject or a module, closed interaction is required between the facilitator (course advisor) and the content provider (lecturer or tutor) for the seamless integration of the technical contents within the target competency framework. The focus of the delivery phase is on the student's learning where actual learning takes place through rigorous interactions within the structured learning program and learning pathways, assisted by the course advisor as well as the respective tutors. A computer-based self-assessment toolkit with a comprehensive reference to professional competencies allows students to assess their strengths and weaknesses against given target outcomes. The results of such self-assessment allow students to reflect on the knowledge gap within any professional setting. Once the preliminary reflection is demonstrated, a customised learning program and the specified learning pathways facilitate progressive development of the competency and meeting the specific competency targets. The progressive learning process is facilitated by a peer feedback mechanism within the team learning environment.

In the review and update phase, all the participants interact closely in reviewing and providing feedback for continuous updates. Self- and peer-reflection reports generated using the computer based toolkit is the key to achieving target outcomes in this process. Moreover, such dynamic interaction and continuous reflection allow for the integration of student feedback for further model enhancement.

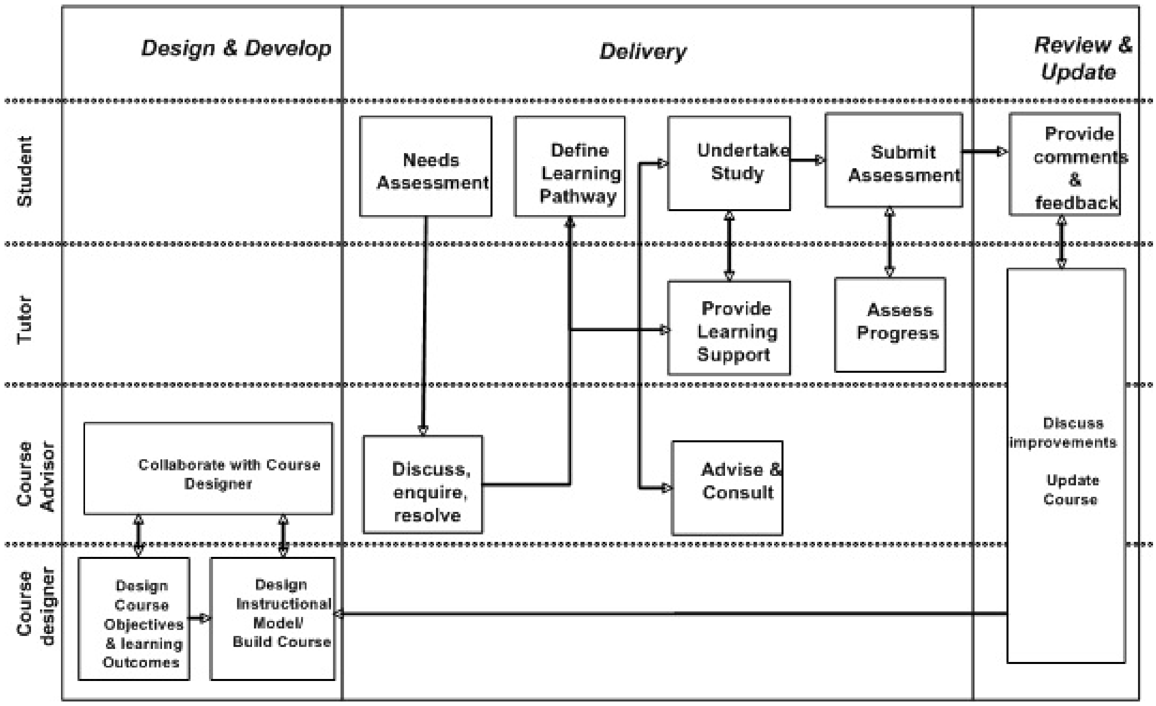


Figure 2: The Pedagogical Model

3.2 Self-Assessment Framework

Figure 3 shows a high level framework for the self-assessment process. As seen, there is an entry level compulsory subject or module followed by a few performance parameters, such as understanding of the professional strength, gap analysis and progressive development towards meeting a specific target outcome at the end.

The entry level module, as “Project Management Framework” allows students with cognate as well as non-cognate professional backgrounds to develop an understanding of the global standards of project management competency framework (Crawford, 2004; PMBOK, 2004). A comprehensive competency matrix has been developed based on the organisational and project management competency standards set by the leading professional associations (e.g. Project Management Institute, International Project Management Association, Australian Project Management Association etc.) (Crawford, 2004).

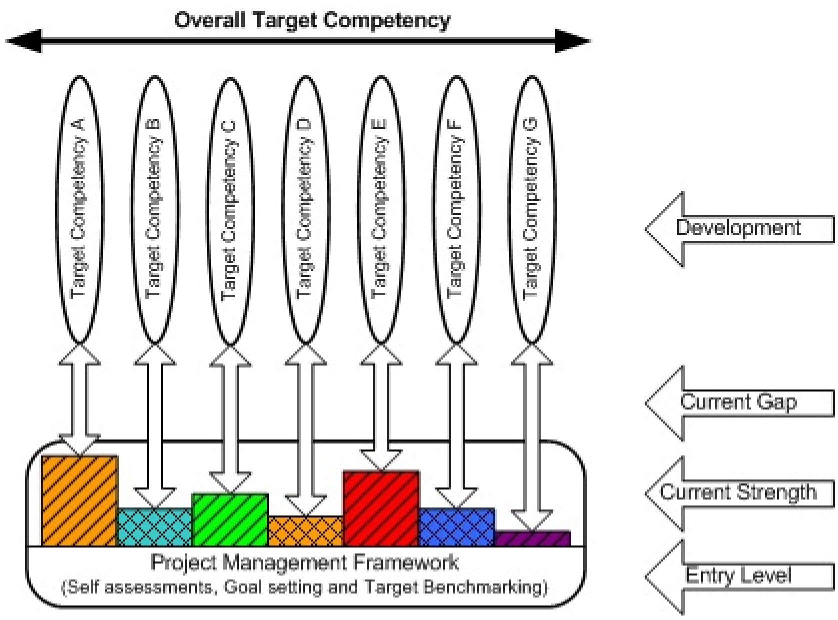


Figure 3: Broad Architecture of the Framework

Based on a thorough review of these available project management standards in global context, a complete list of high level competencies has been developed across three core areas, namely *technical project management competencies*, *organizational competencies* and *socio-cultural competencies*. The competencies are then mapped against a range of low level indicators which can potentially be measured or reflected in the assessment process. A computer-based in-house self-assessment toolkit has been develop capturing the competencies and associated indicators for facilitating student’s self-assessment on their generic and technical strengths. The resulting assessments of the competencies allow the students to evaluate knowledge and competency gaps. A notional professional development plan is then developed by benchmarking the self-learning and progressive development strategies towards meeting the target competencies over a specific period. The target competency may vary from student to student and depends on the relevant business roles in a specific organisation (Figure 2). Thus the professional development plan for each student is uniquely devised based on the strengths, weaknesses, opportunities and threats experienced in individual context.

3.3 Learning Pathways

The overall framework facilitates dynamic interactions and communications for allowing reflective learning and progressive development. A typical module aims to capture all the learning and teaching components from the student's perspectives with the following key features:

- *Introduction* – outlines the profiles of the module's educators and available teaching assistance, if any. This section also provides a brief on what to expect in the course module, any text books, and special requirements, e.g. a spreadsheet program.
- *Outcomes* – this feature specifies the learning outcomes for the module. Indifferent to outputs in studying the module (like assignments), outcomes are competencies, or knowledge and skills achieved during the learning process.
- *Self and Peer Assessments* – outlines the academic assessment criteria and the assessment structure of the course module. A major assessment component is the participation rate of students within the team learning environment facilitated by the system. Both self and peer assessments are required among the students so that the results of such assessments are can be objectively summarised and appropriate skill-gaps are quantified before developing the individual professional development plans (PDPs). It is worthwhile to note that educational substantiation with relevant evidence is one of the key aspects in making claims on the competency at a particular level.
- *Activities* – depicts the learning activities and tasks that need to be conducted by students or groups to gain academic credit. Typically three to six assignments are given in any course module. The learning activities are typically three fold: *start up exercise*, *case based application* and *individual reflection and demonstration*. Startup exercise is designed for students to expedite learning of the fundamental knowledge. The case based application allows students to first undertake a comprehensive literature review for developing a best practice model and second to apply the best practice to devise an appropriate solution on their selected case projects. Individual reflection and demonstration based on the self-assessment of the competencies allows students to demonstrate their progression and achievements in a personalised and guided environment. Each assignment has guidelines and relevant learning notes which can be downloaded.

As seen from the above sample of a typical module outline, it is obvious that a dedicated learning management system is required to deliver the embodied education/training philosophies. The design of the module with such reflective learning process has capability to comprehend online delivery as well. Since one of the main goals of reflective delivery is to extend the education globally, and reach out to untapped world markets, it is prudent for these education systems to be accessible over the Internet. Today the Internet offers a very cost effective solution to online education delivery. All types of media (e.g. word processing documents, video clips, picture files, sound files, etc.) to be transmitted, viewed, edited and played over Internet.

4. Application of the Framework

As mentioned earlier, this model has been designed based on the author's experience with delivery of online education over a number of years. Though no systematic documentation or recording was taken during the time, observations and experience have provided the following proven successful teaching and delivery approaches:

- *Group learning and independent learning* – Group/team learning provided a means for students to learn more effectively resulting in a network of common cooperation and collaboration. Independent learning proved effective where educators did not provide a 'cookbook' approach to learning. Being a graduate level program the key was to provide challenging tasks for different minds and to perhaps change old mindsets via challenging tasks.
- *Competency-based learning* – Proved successful in this type of management program. A 'hands-on' application of PM theory to work place integration proved effective. Just relying on a 'body of knowledge' was not good enough. Rather, it was the exchange of information, concepts, ideologies, and so on that were more important.
- *Educator responsiveness and feedback* – Since students came from all corners of the world it was imperative that students receive feedback on questions they posted and more importantly receive assignment feedback rapidly. Since the Internet and computers are what students predominately interact with, it was imperative that communication would occur through the system's email and discussion forum without relying on external means, which was efficient and spontaneous.

The case study showed that success of a semi-online program with clear reflective learning process can be attributed to the delivery mode and design of a self-driven learning program. No doubt that the IT systems form an integral part of the education service and must be considered carefully before being implemented. The system itself, if not properly implemented, could 'bog down' key resources, and the focus may be turned away from delivering a quality education in the process.

Figure 4 shows an outcome of a goal-setting exercise that students need to perform before entering any formal module. The model allows students to work through a number of project management competency matrices such as socio-cultural, technical and organisational competencies, assessing strengths and weaknesses in the area. The result of this goal-setting exercise allows students to feel the competency gap between the current and desired competency levels. The assessments are then combined to get a holistic evaluation of personal as well as professional attributes before selecting subject matter for further developments.

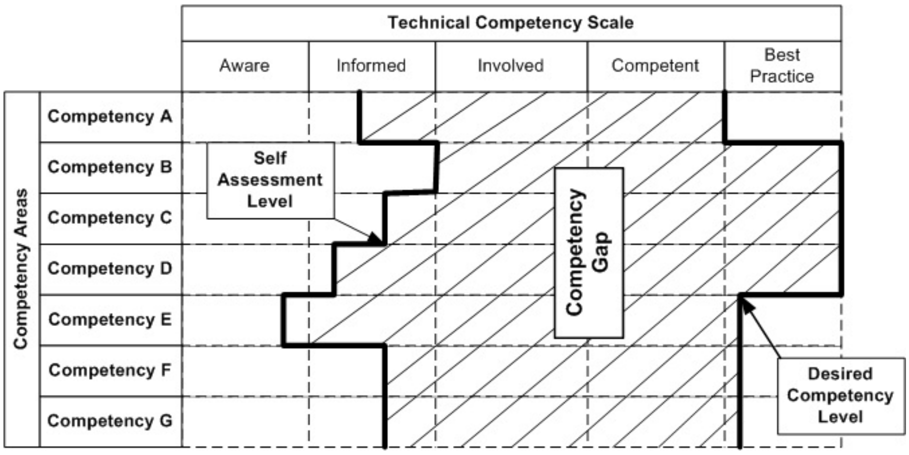


Figure 4: Goal Setting Framework

Such assessment exercise can be undertaken from a distance using a secured IT platform. A notional professional development plan is then developed setting up the desired competency levels across the global competency matrix and relating to the respective business roles.

5. Case Study

Though the paper claims that competency based education is possible by advocating an appropriate reflective learning process within the educational model, questions persist regarding the parallel evolution of related roles, curriculum supporting the development of professional skills and finally formal degree programs. Researchers have provided both positive and negative insights regarding competencies associated with distance learning. These discussions are important in understanding the perspectives of both emerging and new professionals in the field and provide implicit signals as to the ways in which the mature professionals can be trained. The aim of the case study is to further clarify the model in terms of progressive learning, reflections of competencies through the exploration of a typical graduate student perspective. It is worthwhile to mention that the output chart provided in the paper is hypothetical due to sensitiveness in publicising original student's result.

5.1 Self-Assessment and Professional Development Planning

As mentioned earlier, the overall competency framework for each module comprises three broad categories of competencies relevant to the target knowledge areas of the project management profession. These are: *project management, organisational management* and *socio-cultural aspects.* The project management focuses mainly on the project management functions specific to the technical competencies. The organisational management functions are specific to project-based organisations including organisational structures and capabilities for successfully delivering the projects. Socio-cultural management functions are based on soft competencies associated with project management practice.

Figure 5 shows the levels of self-assessment along with the expected goals against some of the project management functions. A 5-point likert scale was used to measure the competencies on the management functions with an incremental order of 20% progression from beginning towards the completion. As can be seen, students' competency levels at the beginning are assessed and target outcomes are set identifying the gaps for further development.

The similar outcomes of self assessments are expected along target competencies in both project organisational competency and socio-cultural competency areas. It is worthwhile to note that all these competencies are developed in team learning environment where students are assigned to a group of 4 to 5 in the class. The group assignments are also set out to facilities team learning in the class. Outcomes of such self-assessment exercises with clear reflections on the competency claims entirely depend on students' professional as well as relevant academic background. Targets are also set as per the personal as well as professional requirements associated with any business roles. While the learning road map may be similar across a given class size, the target achieved or reported at the end depends on students' personal and professional judgements.

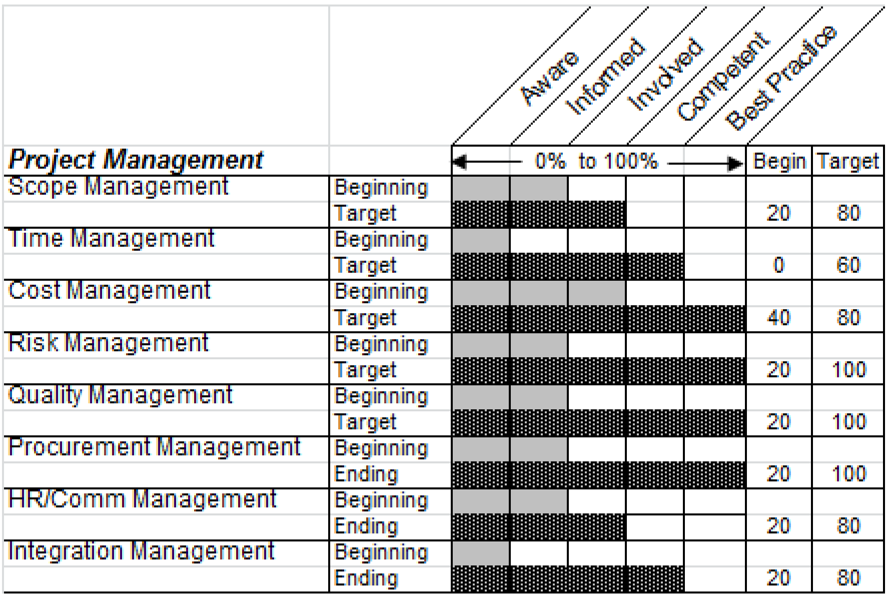


Figure 5: Beginning and target competencies in project management

5.2 Competency report

Figure 6 shows the comparative report with the analysis of learning progression within a set boundary. As can be seen, the competency achieved (refer to the rows denoting 'ending' against each management function) is shown along with the levels at the beginning as well as targets. For instance, beginning and target competencies of a given student on *Scope Management* in project management aspect are 20% and 80% respectively. After completion of the module, the student reports that 40% competency has been achieved against the target of 80%. This may be a realistic reflection of what the student has actually achieved in terms of learning outcomes of the module.

In this case, there is a clear need to undertake further course of actions in developing and closing the gap by an additional 40% to meeting the target. The strategy for such development is normally tracked through professional class presentation and the reflective final report with an idea that a solution may be devised in the model in its dynamic review process.

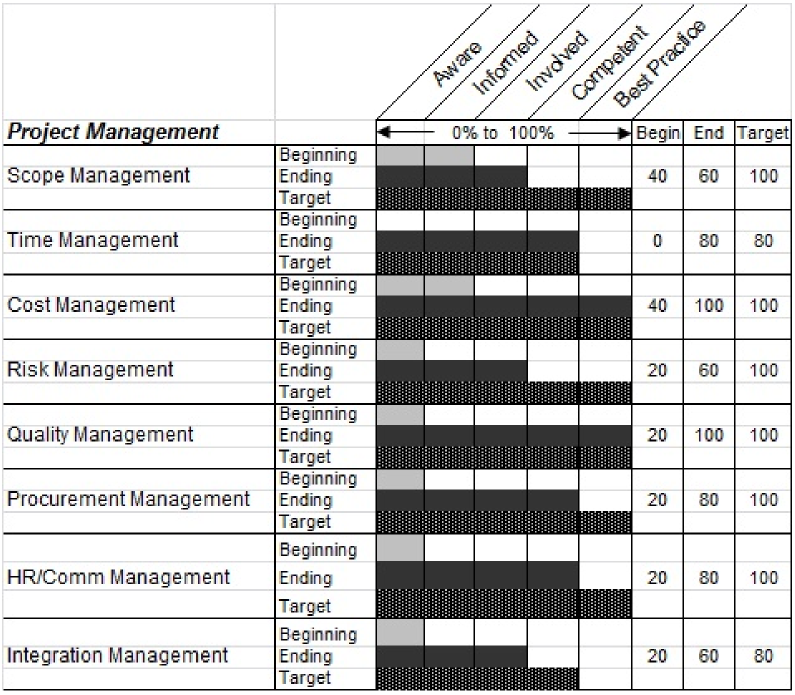


Figure 6: Acquired competency in project management

The model advocated in the paper emphasises significantly on the self-reflections as opposed to the traditional one way lecture based approach. Academic research is the key to developing the knowledge of the subject matter. Hypothetical analysis allows students to devising solutions for given problems facilitated by the educators as part of pilot exercises. Once the level of knowledge is acquired at an appropriate level, the same needs can be demonstrated by applying on a case project. The required technical competencies are assumed to be achieved by such exercises throughout the module. Similarly, socio-cultural competency is developed through mechanisms such as peer discussion, group discussion and self-reflections.

6. Conclusion

This paper highlighted the fact that true educational outcomes experience in traditional teaching model can well be replaced with appropriate pedagogy for reflective learning and flexibility in the professional education. The rapid growth of virtual/online programs along with easy access to lose information has changed the way education is being taught and delivered. Validity of research based pedagogical development is becoming important in the value addition process of the delivery of knowledge to the wider community. This is because of increased demand for continuous professional development to meeting or succeeding competitive advantage in corporate business environment. Based on a competency based reflective learning concept, this paper presents a self-learning model that ensures students meeting the learning challenges with their inherent professional and managerial skills. Pedagogy of the reflective learning has been demonstrated by using delivering construction management education at the University of Melbourne. The competency based model developed from the leading project management body of knowledge has proven to be quite effective integrating educational principles and industry practices within the project management profession.

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Introducing Mobile Technology into the Construction Management Classroom

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Abstract

Mobile technology devices, such as iPads and smart phones, are becoming increasingly popular and the US construction industry is beginning to adopt these technologies. Companies often look to their younger, newer employees to drive the adoption of technological change because they are assumed to be familiar with the latest technological innovations. Likewise, it is often assumed that university students own and use these technologies and that no introduction to them is necessary. In reality, currently only about one third of US college students own such devices and incorporate them into their daily routine.

This research investigates the introduction of the iPod Touch mobile device into a freshman level construction materials and methods course. The devices are incorporated into the course in three ways: (1) for the use of flashcards, so students can study their vocabulary wherever they are; (2) for scavenger hunts, where students look for examples of construction materials and building techniques across campus; and (3) for creating short video tutorials of construction processes that will be shared with future students. This paper discusses student reactions to the mobile device, as well as these academic uses for the device.

Keywords: mobile technology, education, construction materials, m-learning

1. Introduction

Mobile technology devices, such as iPads and smart phones, are becoming increasingly popular and the US construction industry is beginning to adopt these technologies (Study Says, 2012, Van Hampton, 2011). There are hurdles for construction companies to clear before these devices become ubiquitous including cost, internet access (Wi-Fi), durability, and jobsite safety (Walbridge Restricts, 2010). Typically, companies look to their younger, newer employees to drive the adoption of technological change such as this because they are assumed to be familiar with the latest technological innovations.

Similarly, in a university setting, it is often assumed that most students own and use these mobile technologies daily and that no introduction to them is necessary. In reality, only about half of US college students own internet capable handheld devices and less than one third of those use the internet capabilities in their daily routine (Smith et al., 2009). This means that only about 15% of college students owned and used the internet on a mobile device on a daily basis in 2009. The percentage of student users has certainly increased over the last two years and might be as high as 30% today, based on the results of informal polls by the researcher in the classroom. Cost is a major reason why students do not own an internet capable device, or if they do own one, why they choose not to use the internet capabilities (Smith et al., 2009).

Examples of formal use of mobile technology in the classroom, commonly referred to as mobile learning (or m-learning), are scattered across disciplines and comes in many different forms. This work looks at the introduction of the iPod Touch mobile device into a freshman level construction materials and methods course. Device use is incorporated into the course in three ways: (1) for the use of flashcards, so students can study their vocabulary wherever they are; (2) for scavenger hunts, where students look for examples of construction materials and building techniques across campus; and (3) for creating short video tutorials of construction processes that will be shared with future students.

2. The Course

This phase of the research project was carried out with a group of 32 undergraduate students in a freshman-level construction management course entitled “Construction Materials and Methods” at Boise State University in the spring semester of 2012. This course is required for construction management (CM) majors and minors and is a three-credit course with 45 hours of classroom instruction. The course introduces students to construction methods and materials used on building projects, with three main objectives:

- Demonstrate knowledge of the methods and equipment commonly used to construct buildings including the foundation and framing systems.

- Identify and discuss the technical aspects of basic building materials such as steel, concrete, masonry, and wood.

- Utilize correct terminology and nomenclature associated with the materials, methods, equipment and building components found on building construction projects.

These objectives are divided into five topical areas for testing purposes: foundations and construction related math, concrete, masonry, steel, and wood and light gauge steel framing.

Of the 32 students enrolled in the course in spring 2012, 16 formally declared CM as their major, five declared a CM minor, and 11 were non-majors/minors. Attendance at lectures was mandatory and an 89% attendance was achieved. Two students did not complete the course, so not all data presented totals 32 students.

Prior to the changes described here, the assessments for the course comprised five paper-based exams with multiple-choice, true/false, matching, and short answer type questions (16% each, with lowest score dropped, for a total of 64% of course grade), participation and attendance at lectures (6% of course grade), and a comprehensive paper-based final exam with multiple-choice, true/false, and matching type questions (30% of course grade). Comprehensive study guides are made available one week prior to each exam. No-stakes (optional) online formative assessments are also made available for the students to use as study quizzes.

In the spring semester of 2012, the course was modified to incorporate m-learning by adding three aspects to the course: using flashcards, participating in scavenger hunts, and creating video tutorials. The flashcards were optional and had no course grade associated with them, but it was hoped that indirectly they would help students have increased exam scores. The scavenger hunts and video tutorials counted as homework assignments worth 8% of the course grade. The five exams were lowered from 64% to 56% of the course grade to account for the added homework.

The flashcard portion of this project was developed as a result of the instructor's desire to help students who were struggling in the course, while genuinely attempting to do well. Based on statements from several students, they were studying and making efforts, but were not passing the exams. This project was created to help students better assess their readiness to take an upcoming exam and consequently improve their self-knowledge and self-regulation. Self-knowledge is the ability to accurately judge one's level of knowledge and self-regulation is the ability to adjust one's behavior to ensure that acquisition of the missing knowledge is successful (Ibabe and Jauregizar, 2010). It was intended that exam scores, particularly for these struggling students, would increase. Six sets of flashcards were made available for the students to use - one set for each exam.

The scavenger hunt portion of this project was developed to increase students' engagement in the course content by helping students realize that what they are learning in class mirrors what they encounter in the real world. Most students in the course walk across campus and never notice all of the examples of construction materials around them that are identical to those discussed in class. The students were required to complete one scavenger hunt assignment and had the option of completing an additional one.

The video tutorial portion of this project was developed to improve the depth of student knowledge and further immerse them in the course content. The short (3-5 minute) tutorials of construction processes were created by the students and will be shared with future classes. In order to teach something, the students must know their topic very well. The videos also allowed students to practice their communication skills. The students were required to create one video tutorial assignment and had the option of completing an additional one.

Beyond the use of a mobile device to study or complete assignments, using the iPod Touch mobile device exposes students to real world technology applications that are becoming a standard in the construction management field. The iPod Touch is essentially an iPhone without the phone portion and it can only access the internet with a Wi-Fi connection.

3. How Did It Go?

The iPod Touch mobile devices were provided to the students free of charge for the spring 2012 semester. They were given an orientation that included how to set up the device, how to connect to their university email account, and how to download an app. The students were encouraged to use the device as a personal device, to put their music on it, check their email with it, and otherwise use it as if it were their own.

By providing the mobile devices to the students, most of the cost issues were avoided. Students were still responsible for paying for any apps, however. This is similar to them being responsible for the cost of required textbooks, though all attempts were made to keep the app cost low so as not to create an additional monetary burden on the students. An additional benefit to providing the devices was that all students in the course had the same device, eliminating issues of them having different versions of the device, or having devices that use a different platform (iOS versus Android, for example) where the same app may not be available.

Many of the students were very apathetic about receiving their mobile device, which was surprising; the researcher expected the students to be quite excited about the devices. Half of the class claimed to already own an iPod Touch or an iPhone, which may explain the apathy in part, although all but four of the 32 students chose to borrow the new device for the semester. The apathy may actually have been a masked concern for what they might have to do with the device and a perception of possible ‘extra’ work. Only a few students were visibly nervous about learning how to use the new device.

3.1 Flashcards

The flashcard portion of this project used the app, Flashcards Deluxe (Thomason, 2011). The flashcards were created in a Google Docs spreadsheet and were limited to terms and definitions. By sharing the file with all of the students in the class, they could easily download the flashcards into the flashcard app. The app is very simple to use and has many options to help the students, including the ability to read the flashcards to the student, create multiple-choice questions to quiz them, and even quiz their spelling of terms. It is also capable of including images on the cards, although that feature was not used for the flashcards provided to students.

To collect data on student use and satisfaction with the flashcards, a brief one-page questionnaire was attached to the back of each student's exam. The questionnaire asked if they had used the flashcards. If they had used the flashcards, students were asked if they thought it helped them perform better on the exam, why or why not, and what might have been more helpful. If they had not used the flashcards, they were asked why they did not, and whether they thought it would have helped if they had used them. The questionnaire also asked about the amount of study time spent for that exam, along with the student's methods of study, and what grade they expected to receive on the exam.

Altogether, the students were asked to complete the questionnaire six times – once for each exam. The response rate for the questionnaire varied based on the exam, but ranged from a high of 90.3% (28 of 31) to a low of 76.7% (23 of 30) for an overall response rate of 80.2% (146 of 182). Of the students who responded, 74.7% (109 of 146 total responses) self-reported that they used the flashcards and nearly all of those students thought that they helped (98 of 106 total responses = 92.5%). Of those students who reported not using the flashcards, a majority (19 of 29 total responses = 65.5%) thought that they would have done better on the exam had they used them, and an additional four students thought the flashcards might have helped (4 of 29 total responses = 13.8%). Some sample comments from the students regarding why they thought the flashcards helped are listed below:

> "helped me learn the terms fast. Easy to carry around."
>
> "was able to remember more vocabulary"
>
> "more convenient than my notes"
>
> "everything helps and I use it walking between classes"

There were very few negative comments regarding the use of the flashcards. Several students commented that the flashcards could be improved by adding pictures to them. One student said they did not have enough money to download the app, which was a little concerning as it only costs $3.99, and one student did not download the app because Wi-Fi was not available at home and they kept forgetting to do it on campus. To address any possible financial issues, iPads available for free checkout at the university library were equipped with the flashcard app.

When studying for the six exams, students reported using the flashcards an average of 1.52 hours per exam, which was slightly less than half of their average study time of 3.66 hours per exam. However, there was no statistically significant difference for any of the six exams when comparing mean exam scores with those from eight previous semesters. Table 1 shows the descriptive statistics and 1-tailed Independent t-test for each exam in spring semester 2012, compared with eight previous semesters.

Table 1. Descriptive statistics and 1-tailed Independent t-test table

Test #	**Group**	**n**	**Mean (SD)**	**t statistic**	**1-tailed p**
Test 1	8 past semesters	300	83.01 (10.08)	0.19	0.5750
	Spring 2012	31	82.65 (11.97)		
Test 2	8 past semesters	294	79.19 (11.38)	0.27	0.6081
	Spring 2012	31	78.60 (12.73)		
Test 3	8 past semesters	285	79.81 (11.93)	0.45	0.6740
	Spring 2012	30	78.77 (12.90)		
Test 4	8 past semesters	294	81.02 (12.14)	-0.33	0.6281
	Spring 2012	30	81.78 (11.84)		
Test 5	8 past semesters	291	77.09 (12.45)	-0.47	0.3185
	Spring 2012	30	78.22 (12.21)		
Final Exam	8 past semesters	291	79.81 (9.02)	-0.11	0.4562
	Spring 2012	30	80.00 (10.96)		

Beyond the predominantly positive views the students had regarding the flashcards, the apathy surrounding the mobile devices seemed to largely disappear by the time the scavenger hunt and video creation assignments were introduced. Students began to visibly use the devices before class and were discussing the course material more than was usual based on the instructor's experience from eight previous semesters of teaching this course.

3.2 Video Tutorials

The video tutorial portion of the project made use of the video capabilities of the iPod Touch mobile device. Students were asked to create a 3-5 minute video explaining a topic covered during the semester so that it would be understandable by someone with no construction experience. Some examples of video topics included: an explanation of what the angle of repose means and how to tell the difference between an steel I-beam (S-shape) and a wide flange (W-shape).

The students were able to shoot video directly with their iPod Touch. To edit the video, they used the free app, Splice – Video Editor (Splice, 2012). This app allowed them to edit their clips and add titles and music, all from their iPod.

From a technology standpoint, most of the students were able to make and edit a video without any major issues. The biggest hurdle for students was the submission of the video for grading. Many alternatives were offered, but the only method that was consistently successful was for them to post their video on YouTube and share the link. Most students did not prepare for the extra time that their submission would take and many assignments were not completed until after the official deadline had passed. Given that this type of assignment was new to most of them, some leniency was granted for this first assignment.

Some students had a lot of fun with this assignment and it was obvious that they not only enjoyed making their video, but that they learned about a particular topic much more deeply. Other students treated it as just another assignment to complete, and four students of the 30 active in the course made no attempt at this assignment.

3.3 Scavenger Hunts

The scavenger hunt portion of this project made use of the camera on the iPod Touch mobile device. Students were asked to locate examples of construction materials and methods from a list of terms that were provided to them. Some examples of terms for the assignment related to concrete included: expansion joint, broom finish, cold joint, chamfered corner, and waffle slab. The assignment required them to take a picture of each item that they located, label the picture correctly, and document on a map where the item was found. The intent was for the assignment to be created as an interactive Google map that was shared with the instructor for grading.

Many students had trouble with the technological side of this assignment, i.e., creating the Google map, incorporating their pictures into it, and sharing it, so alternative methods of presentation were accepted. Even with the technology issues, most students enjoyed this assignment and a number of them commented that it helped them to prepare for the upcoming exam. One student even noted that this assignment was more valuable to him for studying than the flashcards were.

4. Conclusions

Of the three uses of the iPod Touch in this course, the flashcards were one of the student favourites. The flashcards received a good deal of use over the semester and were rated favourably on the questionnaires attached to each exam.

The other student favourite was the scavenger hunt. Students were required to complete one additional assignment and they were given their choice of creating another video or completing another scavenger hunt. Overwhelmingly, students chose to complete a second scavenger hunt (26 scavenger hunters vs. 4 video creators). The reasons for this likely varied, but the open-endedness of the video assignment was expressed as much more challenging for many of them than the well-defined scavenger hunt.

While the overall project is in its infancy, it holds much promise. Mobile device use in this course did not improve exam scores, but that is only one possible measure of success on this project. Perhaps equally important are gains in students' self-knowledge and self-regulation (to be discussed in a separate paper), and increased engagement in and excitement about the course content, which was definitely accomplished. Having students complete the course with positive perceptions regarding mobile device use is also an important measure of success.

Ultimately, even if significant gains are not found in these areas, incorporating mobile devices into the classroom is potentially valuable as long as it does not harm to the students and does not become a financial burden to them. It allows students the opportunity to incorporate mobile devices into their academic and personal lives, which will likely be a skill they can leverage, both in internships and full-time employment in the construction industry.

5. Acknowledgements

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The Situation Engine: A New Approach to Work Integrated Learning

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Abstract

Work Integrated Learning (WIL) is widely acknowledged as providing an excellent complement to academic study in vocational degree programs such as construction management. However, the current context of higher education, with its increasing enrolment numbers and tightening of available resources, makes the delivery of effective WIL quite problematic. One key element of WIL is the situated nature of the learning experience, where practical engagement with a work situation is core.

The Situation Engine represents a new approach to situated learning. A Situation Engine is an application that provides for specific and managed practical building and construction experience to be made available to students through advanced digital technologies. The same engine can drive a multitude of learning situations. To be effective a Situation Engine must provide tailored experiences of practical situations using the utmost in virtual reality capabilities.

This paper will describe and discuss the rationale for a prototype Situation Engine specific to teaching and learning residential construction technology. The particular development methodology framework used in the design and development process will be presented and reviewed. The prototype Situation Engine system has been trialled with 1st year undergraduate construction management students and is evaluated in that context.

Keywords: Work integrated learning, Situated learning, Serious video games

1. Work Integrated Learning

Programs of study with a specific focus on a particular occupational outcome (such as construction management) are increasingly being shaped by the imperative of employability. Employability skills in the context of higher education tend to render down to the same key factors: communication, teamwork, problem-solving, initiative, self-management, planning, life-long learning, etc. (see for example DEST, 2002). In a recent review of graduate employability (Cleary et al, 2007) the broad notion of Work-Integrated Learning (WIL) was proposed (logically) as the most important mechanism available for the development of employment skills. This broad notion of WIL refers to any practice-based experiences integrated into the higher education program of study. Practice-based experiences might include such activities as practicums, industry placements, case studies, role play and site visits. Of course, the effective integration of such practice-based experiences into the formal study program is what remains most crucial (Billett and Henderson, 2011). Arguably, however, what makes WIL so critical to the development of employability skills is the situated nature of learning itself.

Situated learning offers a particular orientation to teaching and learning. That orientation privileges a learning process based on direct personal observation. Direct personal observation of how practitioners and the industry actually work (Wenger, 1998: 3-17). Under the rubric of situated learning, the development of knowledge and skills requires the learner to engage directly with the socio-cultural practices that constitute a particular domain of professional practice. The socio-cultural practices are the shared routines, sensibilities, vocabulary, styles, artefacts, procedures, etc. that constitute a particular field of practice (Wenger, 1998: 73-84): what Schön (1983: 138) refers to as the language, media and repertoire of a particular professional community.

To be effective, participation in a community of practice must be legitimate. To be legitimate, the WIL experience must offer a framework for participation that is both competent and culturally attenuated to the requirements of learning (Lave and Wenger, 1991). A competent framework is one in which the learning outcomes are expressed in terms that are both deliberate and intentional (Washbourn, 1996). That is, the WIL experience must have explicit skills development that is demonstrable and assessable. A culturally attenuated framework is one where the process of learning is managed effectively. To be managed effectively the situation needs to be controlled from a pedagogical perspective. That means academics must be able and willing to police the specific WIL experience directly. Such policing has to go well beyond just the vetting and induction of a host organisation, for example.

In summary, situated learning places two key requirements on WIL. On the one hand, it must provide for explicit student development and assessment. On the other hand, it must provide a level of control over the learning experience. Those many practice-based experiences that do provide for explicit student development and assessment also tend to be problematic when it comes to exercising control. For example, an industry placement can develop important practical skills but the resources required and opportunities available to target particular skills are often prohibitive. Those practice-based experiences that might lend themselves to more direct control also tend to be more abstract in their learning outcomes. For example, a case study can be selected carefully to address a particular issue or skill but does so vicariously or once removed from the actual activity itself.

The current context of higher education in Australia, as it is elsewhere, is one of broadening access and participation in a climate of structural and organisational change (Bradley et al, 2008). Higher education must cater for increasing numbers of students and do so with a tightening of the available resources. In that context the integration of effective WIL is increasingly problematic. One of the most common strategies to promote learning through/from experience is reflective practice. Reflective practice has become synonymous with an abundant spectrum of approaches, including the keeping of diaries and journals, learning contracts, role play, critical thinking, visualisation, etc. (Atherton, 2005). Almost all of these approaches focus on the recording and subsequent review of accounts (in one form or another) of episodes in the (past) learning experience. What is generally missing is any consideration of how the experiences are to be noticed in the first place. Without first registering an experience as significant, subsequent reflections are going to be fruitless (Mason, 2002). Registering an experience is specifically addressed conceptually in terms of sensitisation, awareness and noticing (Marton and Booth, 1997). The strategies that enable sensitisation, awareness and noticing (learning how to experience), are a fundamental component of any curriculum that promotes a situated learning agenda.

WIL is proving difficult to realise as a legitimate learning experience. The current context of higher education is making that task increasingly difficult. Several key issues have been highlighted in this short consideration from the perspective of a situated learning framework:

(i) the need for effective control of direct practical experiences

(ii) the essential integration of practice-based experience into a formal study program, and

(iii) the practical development of a ‘learning how to experience’ strategy.

A new concept, the Situation Engine, is proposed to address these three key issues. A justification of the Situation Engine concept is presented in that context and a prototype Situation Engine is described. The prototype Situation Engine is specific to teaching and learning residential construction technology and is being trialled with 1st year undergraduate construction management students.

2. The Situation Engine

The Situation Engine is a new concept in WIL. We define the Situation Engine as:

> *An application that provides for specific and managed practical building and construction experience to be made available to students through advanced digital technologies.*

Figure 1 begins to un-wrap this definition in more functional terms. Each specific situation is comprised of: certain environmental conditions (weather, time, location, etc.); objects and their properties (buildings, equipment, materials, etc. with dimensions, mass, movement, density, etc.); actors and their behaviours (characters, interfaces, avatars, etc. with behaviours, scripts, intelligence, etc.); and data feeds (web, video, motion, devices, etc.). Various combinations of environments, objects, actors and feeds constitute a particular situation. Each situation is then articulated as a series of interactions. The interactions are not prescribed, but rather emerge from the basic physics and decision-making that governs the behaviour of environments in certain conditions, objects with certain properties, actors with certain behaviours and feeds with certain data manipulation. Howsoever the complex interactions resolve themselves at any given moment in time, is then rendered to the user as a display of some form (screen, goggles, digital cave, 3D, soundscape, etc.). The user interface needs to deliver an immersive, first-person experience of the situation to the user as it unfolds. The more realistic the immersive experience the better. First-person engagement is critical to an immersive experience in this context, as the specific situation is then presented as a person would typically engage with the world. Clearly, the same Situation Engine is intended to drive a multitude of tailored learning situations.

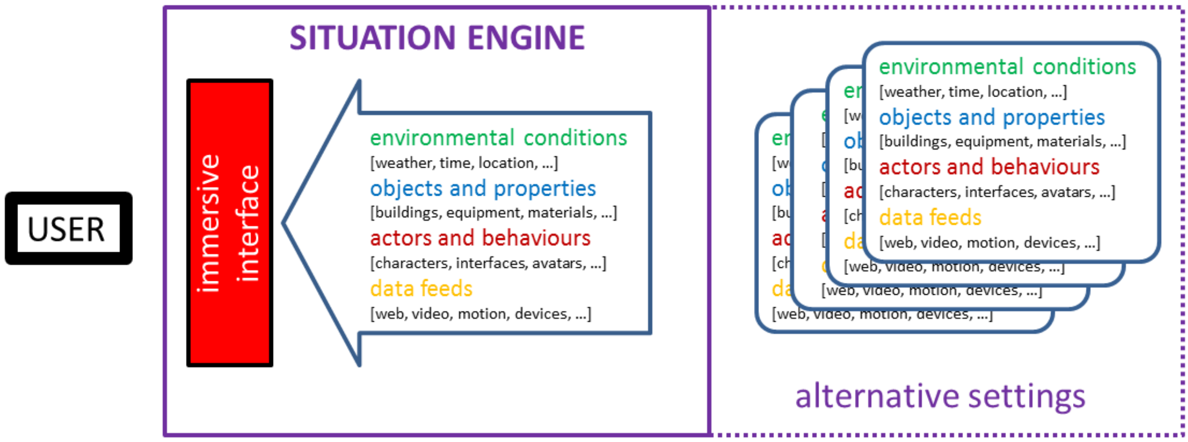

Figure 1: Concept Structure for a Situation Engine

The role of the Situation Engine is not merely to provide access to particular combinations of knowledge. That approach would associate specific learning outcomes to particular situation settings. It conceives of learning as a process of building a particular understanding from a prescribed series of building blocks. An alternative approach is to conceive the student as an active constructor of their knowledge in each situation setting. This latter approach recognises that learners themselves create knowledge through a subjective construction across different situations and experiences. The Situation Engine might afford particular learning outcomes, but the user might never construe their actual experiences to those particular learning outcomes. It is more likely that the simpler levels of knowledge (the facts and concepts) and deeper forms of understanding (the associations and connections) will act in concert (Billett, 2009). The goal-directed activities, performance monitoring, self-management, etc. all help the learner to generate understandings that reach beyond the intentional components of each situation. The learner might choose to reconcile, reject or ignore their learning experiences, which in any event may themselves be partial, incomplete or misconstrued.

The subjective construction of knowledge is as much dependent on the level and effort of the student as it is on the teacher. For such an approach to be effective the student disposition and motivation is important (Billett, 2009). Where learning is perceived to be of personal benefit, interesting and/or engaging, for example, these will more likely lead to richer and more substantive learning experiences. Fatigue, familiarity, complexity and a range of negative personal dispositions and behaviours will impact on the effectiveness of the Situation Engine, including attitudes to the use of new technologies and the pre-mediate experiences of the users (Valsiner, 2000). Luckin (2008:449) refers to a "learner centric ecology of resources" to broaden the consideration of new teaching technologies beyond their own technical design. This proposes that the traditional model of technology development must be extended. A design and evaluation framework based on de Freitas and Jarvis (2006) is proposed for the implementation and testing of the Situation Engine. This framework takes the more general form of a structured and rigorous consideration of the context (including the resources available to deliver, access and support the application), learner specifics (including learner attributes and preferences), representation (the form or mode in which the content of the application is made manifest to the user – explicitly, implicitly, vicariously, etc.), and pedagogy (the theory and practice models that frame the learning activities) within which the Situation Engine is to be deployed.

3. A Prototype Situation Engine

The target curriculum for the current Situation Engine development is the 1st year course of a 4 year program of undergraduate study in construction management and property. The course is the first in the program of study to introduce students to construction technology. It deals with the functional requirements and construction methods specific to single-storey residential/domestic construction typical in Australia. As such the course examines a range of key technical aspects, including: brick and timber frame construction methods and materials; domestic joinery; staircase construction; finishes; plumbing, drainage and electrical services; methods of setting out and supervision. The course also involves developing skills in on-site observation and the production of housing site reports.

A formal process of human factor analysis using focus groups and task analysis has been undertaken, along with an analysis of the learning needs of current students (Newton, 2012). For instance, the learning needs were assessed by reviewing the performance of several hundred students in their end-of-year examinations, to identify those topics where students were having problems and the typical mistakes they were making specific to construction technology. A small reference group of users has been established to trial prototype systems and evaluate various implementations. Formal evaluation of the current prototype is being conducted using a control group of students having no exposure to the Situation Engine, where the placebo is standard revision and tutorial support.

The most sophisticated interactive virtual reality simulation environments with practical application to teaching and learning are to be found in video games. Video games use high performance graphics engines to render moving photo-realistic scenes in real-time and 3D along with the potential for associated surround-sound audio and tactile feedback to a user who controls the action with a variety of input devices. What is particularly timely about the potential development of video games for learning and teaching, is the recent development in video game technology that has resulted in the ‘game engines’ themselves (the kernel of coding used to drive a collection of actual game implementations) being made available on an open-source basis. Even the most powerful game engines are now relatively cheap to acquire for teaching and learning purposes, are intentionally configured to allow third party modifications to be created and embedded seamlessly into the game engine, and are increasingly supported online by a significant and committed community of users and developers (referred to as ‘modders’).

The specific genre of game selected is termed a ‘first-person shooter’ (FPS). FPS games are characterised by the use of an avatar which presents the first-person perspective that enables the player to see and be seen as a person would conventionally occupy a space (ie. bound by and to one's own body). Other game genres adopt either a more abstract form of engagement (such as the third-person perspective characteristic of games like Sim City, and entirely command-driven game controls) or tend to focus more on the interaction and communication capabilities across a social network (as is the case in Second Life worlds, for example). The specific application is the proprietary video game engine CryENGINE, that features the most advanced graphical, physical and animation technologies (for further information, see http://www.crytek.com/cryengine).

Figure 2: First Person View from the Prototype Situation Engine

The quality of the visual rendering is illustrated in Figure 2, which is a screen grab from the application. It shows a situation where the construction site has been established with some initial plant, facilities and materials – as seen through the eyes of the user avatar. The same site can be used to present alternative situations, with other configurations of material storage, signage, waste management, security, etc. Multiple users can be represented and experience the situation collectively. A building can be constructed from the foundations through to the roof and finishes. At various points a user can interact with the building as it is constructed – checking the placement of reinforcement and formwork just prior to pouring the slab, for example. Users get to see how the work at different stages of construction has been prepared, measure and check sizes and distances, test the bearing capacity of members, assess details against building codes and best-practice guides, etc.

The gaming elements include an accuracy measure that reduces for each mistake made in selecting materials and/or the next step of the construction process. Progress indicates how far through the game the user has progressed. The time taken is measured and displayed, and the sun tracks across the sky and eventually sets each day.

Figure 3 illustrates another aspect of the wider site context. It shows one of the game actors following the partial collapse of a timber frame elsewhere on the site. Students are expected to note the lack of appropriate safety apparel and security fencing. They are required to investigate and determine what factors might have led to the collapse – such as having no temporary bracing, incorrect timber size selection, poor construction management, etc. Practical skills, such as reading and comparing design drawings with as-built construction, can also be highlighted and tested. The intention with every task is to present a situation for the student to experience, individually or as part of a group, and as far as is practicable to allow the user free-range in how they complete each task.

Figure 3: Investigating a collapsed timber structure

The current prototype can also be used to test a students' understanding of related issues, such as safe work practices, material storage and handling considerations, site security, environmental protection, wet-weather hazards, noise pollution, etc.

4. Discussion and Conclusions

WIL is most commonly used to refer to programs where students are physically located in a workplace as a formal part of their studies (Smigiel and Harris, 2007). The intended outcome is for students to learn essential skills that they cannot learn in a formal classroom setting. This paper has taken the broader view of WIL, to include any work-related experience included in a program of study.

Several key issues specific to WIL have been highlighted from the perspective of a situated learning framework:

(i) The need for effective control of direct practical experiences. Without adequate control of the practical experience, learning outcomes can be disparate and varied.

(ii) The essential integration of practice-based experience into a formal study program. WIL can serve to illustrate the theories and concepts presented in-class, and/or be used to test the veracity of the theory against the actual situations encountered in practice.

(iii) The practical development of a 'learning how to experience' strategy. The ability to register and re-register particular situations and situation settings enable, over time, improved sensitisation, awareness and noticing skills.

To address these three main issues the concept of a Situation Engine has been proposed. The concept fits well with the broad definition of WIL, but various implementation issues remain to be addressed. In particular, the subjective construction of knowledge requires a positive disposition and motivation to be effective. Careful design and development of the prototype Situation Engine is required if a range of negative behaviours is to be avoided. The use of a structured development framework has kept the focus on context, learner specifics, representation and pedagogy.

The prototype Situation Engine employs the most sophisticated virtual reality simulation environment available. CryENGINE provides for a first person experience of controlled practical experiences specific to domestic building construction. The current application is being trialled with 1st year Construction Management students to help develop and demonstrate a range of knowledge and skills relevant to domestic building construction. The application can successfully present different configurations (situation settings) of a particular site and enable a range of learning strategies to be examined.

The current implementation is an early version and is now being superseded in response to the feedback and findings of several trials and evaluations. First and foremost the building construction is being completely revised. The initial construction matched exactly the design drawings previously used to support a practical model-building exercise (Forsythe, 2009). New and more sophisticated domestic buildings are being developed. These will also be located in a more urban setting. It is clear that a more constrained site would present more realistic problems of access and material storage. There is also insufficient of the hustle and bustle, noise and people, typical of such construction situations.

Overall, however, the Situation Engine has demonstrated some of the potential that new technologies offer in terms of providing more effective and practical WIL experiences. As the context of higher education seems to continue to require more students be taught with fewer resources, effective development of new teaching methods becomes increasingly critical.

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A Client Support System for Post-occupancy Design Decisions in School Projects

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Abstract

In the UK, the budgetary allocation of publicly funded education is substantial. The capital investment fund for schools gradually grew from £683 million in 1996-97, to £3.8 billion in 2003-04, and subsequently to £8.2 billion for 2010-2011.

Like most buildings, schools and associated facilities are subject to dilapidation, obsolescence, deterioration and change during their service life. Therefore, they require constant upkeep and/or periodic adaptations to change the functionality or improve the performance of the building. This is why up-to-date knowledge and information flow on and about a building is crucial. Although data processing – collection, storage and retrieval – forms a part of a successful knowledge and information management which can guarantee a successful post-occupancy decision process, it is not always sufficient. What is more important is how the data informs decision and knowledge (knowing) processes.

This paper reports on some findings of a research project on post-occupancy design in school projects. First of all a brief overview of key factors, and major players in post-occupancy processes will be provided. We will then establish the decision processes. Decision Support Systems (DSS) will be critically reviewed to correlate the existing context with the means which will be used to offer the most efficient system to support the decisions in post-occupancy design in school projects. The main contribution of this paper however, remains to be the collaborative processes of decisions streamlined to be utilised for creating a post-occupancy framework using the concepts of knowledge and value co-creation. Some indications of the post occupancy design information toolkit (PODIT) which has particularly been developed for this project as a knowledge/value co-creation will be used to clarify on the application of the underlying theory to develop a practical toolkit for the stakeholders in school projects.

Keywords: Building performance, Decision support systems, Knowledge and information management, Knowledge and value co-creation, Post-occupancy processes

1. Introduction

In the UK, the budgetary allocation of publicly funded education is substantial. The capital investment fund for schools gradually grew from £683 million in 1996-97, to £3.8 billion in 2003-04, and subsequently to £8.2 billion for 2010-2011.

Like most buildings, schools and their associated facilities are subject to dilapidation, obsolescence, deterioration and change during their service life. Therefore, they require constant upkeep and/or periodic adaptation to change the functionality and/or improve the performance of the building. Furthermore, unlike manufacturing industries in which the life cycle of the product tends to become shorter in many occasions due to the flow of work, pace of growth and other microeconomics and macroeconomics factors, in the building industry, new technologies, methods and materials are employed to extend the service life of buildings. This on its own highlights the importance of post-occupancy interventions to make constant improvements to the existing building stocks. In addition, environmental concerns and sustainability drivers call for better and longer use of the buildings as opposed to demolition existing buildings and replacing them with brand new ones. For all these reasons – and even if the demolition/rebuild was the ultimate solution – up-to-date knowledge and information flow on and about buildings and how they are managed are of paramount importance in assisting in making more informed decisions if and when any intervention in existing buildings is about to take place.

Although data processing – collection, storage and retrieval – plays a major role is a successful knowledge and information management, which can potentially contribute to a successful post-occupancy decision process, it is not always sufficient. Experience shows that in most of the cases the problem is not lack of data, information or knowledge. The problem lies where it comes to retrieval of the relevant data/information to the decision which is about to be made. What is even more important is how the data informs decision and knowledge (knowing) processes and how different parties participate in the decision process.

This paper reports on partial findings of a research project on post-occupancy design in school projects. It will first provide a brief overview of key factors, and major players in post-occupancy processes. It will then establish the decision processes. A quick review of Decision Support Systems (DSS) will be provided to correlate the existing context with the means which will be used to offer the most efficient system to support the decisions in post-occupancy design in school projects. The main contribution of this paper however, remains to be the collaborative processes of decisions streamlined to be utilised for creating a post-occupancy framework using the concepts of knowledge and value co-creation. Some indications of the post occupancy design information toolkit (PODIT) which has particularly been developed for this project as a knowledge/value co-creation will be used to clarify on the application of the underlying theory to develop a practical toolkit for the stakeholders in school projects.

2. Review of exciting literature

A brief review of literature will be provided in the following sections:

2.1 Post-occupancy decision processes

Post-occupancy intervention decisions on one hand are informed by the process of design decision making (Kelly *et al.* 2005, Hitchcock *et al.* 1998) and on the other hand need to be supported by post-occupancy evaluation (POE). Preiser (2002) explains POE as a process of systematically evaluating the performance of buildings after they have been built and occupied for some time. There are two levels of performance management: performance upkeep and performance adjustment. A number of purposes are fulfilled by carrying out POEs (see Whyte and Gann 2001, Hadjri and Crozier 2009 among the others) and building performance assessment and POEs have attracted a lot of attentions recently. However, they are not yet very regularly carried out in practice, and the outcomes are not routinely available or widely used by most design and building teams (Bordass and Leaman 2005). The focus of this research is obtaining performance feedback on quantitative (building) and qualitative (stakeholder) level using a procedural approach. According to Vischer (2001) a procedural approach that reiterates the need for standardised data gathering, but also includes the requirement to balance qualitative and quantitative datasets, as well as establishing the nature of the focus group to which the information is to be disseminated can be followed for this purpose.

2.2 Major role-players in post-occupancy decisions

According to the literature there are four major factors that can affect post-occupancy decisions these are:

- Design intent and criteria (Perelman *et al.* 2001, Green and Simister 1999, Kelly *et al.* 2005)
- Information and knowledge processes (Bouchlaghem *et al.* 2004, McDermott 1999, Gigerenzer 1996, Galbraith 1977, Winch 2002, Björk 1999, Koutamanis *et al.* 2008, Quanjel and Zeiler 2007).
- Performance monitoring (CIB 1993, Preiser *et al.* 1988, Cory 2001).
- Collaborative working practices (Bertelsen and Emmitt 2005, Emmitt and Gorse 2003, Kalay 2006)

The findings from the study also proposed three additional factors: cost, quality and (lead-in) time.

2.3 Co-creation

Co-creation is a market strategy which is known to have enhanced customer's role in the value-chain by developing its extensionality beyond the traditional definitions. The concept of co-creation expanded even beyond the ‘value’ to ‘knowledge’ as co-creation of knowledge can equally effectively improve the customer’s participation in the value-chain. Coined by Prahalad and Ramaswamy in 2000, co-creation was primarily aiming to harness customer competence. It is capable of helping create mutual values for both the customer and the firm through customer participation beyond immediate marketable values (Zwass 2010). Prahalad and Ramaswamy (2004) later suggested the DART of co-creation (Dialogue, Access, Risk-Return and Transparency) for successful deployment of co-creation in a company. More opportunities for improvement of relationship experience and enhancement of co-creation arise as firm learn more about their customers (Payne et al. 2007; Payne et al. 2009). Sanders and Stappers (2008) use co-creation to refer to ‘collective creativity’. Lawer (2006) suggests eight styles of firm-customer knowledge and value co-creation (Figure 1).

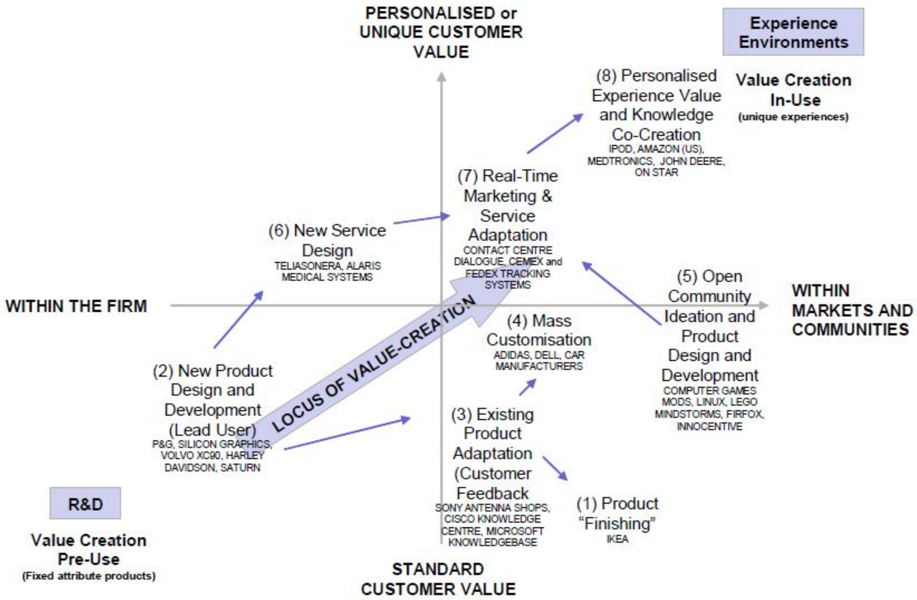

Figure 1: Eight styles of firm-customer knowledge and value co-creation (Lawer 2006)

2.4 Project stakeholders

Part A of the Building Bulletins BB98 (DfES 2004) and BB99 (DfES 2006) define the client team as:

- Local authorities
- Governors, bursar
- Architects
- Senior school staff and governors
- Other stakeholders, e.g. local community groups, and
- The staff and pupils.

This may slightly vary for primary and secondary schools, from city/county to city/county and depending on the size of the school.

2.5 Decision support systems

First coined by Gorry and Scott Morton (1971), a decision support system (DSS) is a computer technology solution to support complex decision making and problem solving (Shim *et al.*, 2002). According to Shim *et al.* (2002) a classic DSS is formed of three components: database (and its management capabilities), modelling function, and the user interface. Ever since DSS has been adopted by and adapted to many disciplines introducing many improvements, including powerful tools i.e. data warehouses, OLAP, data mining and web-based DSS (Kimball, 1996, E.F. Codd & Associates, 1993, Thomsen, 1997), and evolution from individual standalone applications to highly interconnected networks of collaborative support systems [see among the others (Alavi and Keen, 1989, DeSanctis and Gallupe, 1987, Kinney and Panko, 1996, Warkentin *et al.*, 1997, McGrath and Hollingshead, 1994)].

3. Methodology

A literature search was carried out to identify and investigate different areas which may inform the research. This included:

- Post occupancy decision processes
- Major role player in post occupancy decisions
- Co-creation of knowledge and value
- School projects stakeholders in the UK
- Decision support systems (DSS)

Subsequently steering groups were formed to obtain primary data for the research. The steering groups comprised of a sample of primary and secondary school representatives, local authority representatives, building professionals and IT and information specialists. 60 private and public, primary and secondary schools in East and West Sussex (South East England) were selected using simple random sampling (SRS) method. In addition, another 20 invitations were sent to the relevant local authority departments and building professionals. 2 design/academic experts were also invited to serve as independent advisers. The result was a total of 13 members on the steering group representing all identified stakeholders.

Following the primary data collection, selected schools were visited, and school and local authorities were interviewed using semi-structured interviews. This was to acquire detailed and in-depth insight to all the areas which might not have been covered thoroughly in steering group meetings.

At the same time, search for finding the most viable solutions for toolkit development and directed studies were carried out and, research meetings were arranged to explore the applications of proposed toolkit. It was envisaged that such a toolkit requires a user friendly and intuitive Graphical User Interface (GUI), as well as an efficient database powered by an efficient database management system.

To ensure validity and applicability, level of use and complexity of the decision support system for post-occupancy projects proposed through this research, simulated and real cases of making decisions were designed and selected to devise a model-base to test out the first prototypes of the toolkit.

4. Findings and discussion

Based on the literature search 33 post-occupancy decision criteria were recognised and participants in first steering were asked to rate them based on their importance. The findings from the steering group meeting with reference to the literature were used to map and code the 33 post-occupancy decision criteria into different categories. This was informed by the decision structures, the structure and hierarchy of the stakeholders involved and the funding mechanisms both within the school and those allocated by external funding bodies. The participants in steering group 2 gauged those categories based on their priorities in running, managing and budgeting schools. A model was then devised based on the concepts of co-creation in combination with DSS for development of the first prototype of the toolkit (See Figure 2).

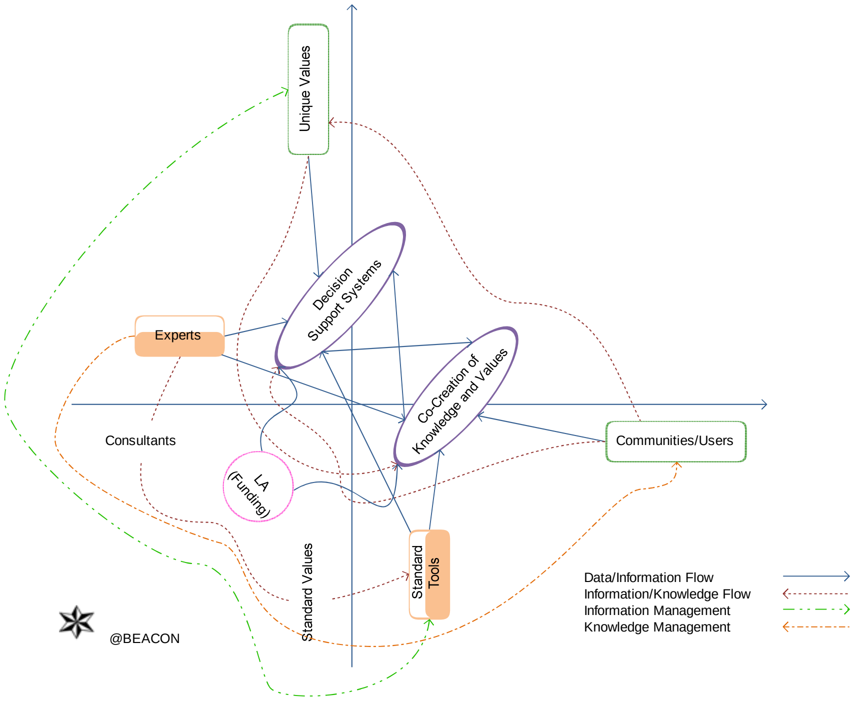

Figure 2: Development model for PODIT based on knowledge co-creation and DSS

Results from the steering groups also helped us map the decision criteria and which requirements are expected by different stakeholders if a DSS is to be employed efficiently. Those findings were then used as the 'context' (decision criteria) and the 'ends' (requirements) in combination with the model as the 'means' to develop the first prototype of the application. Two different interfaces of the first prototype can be seen in figures 3 (data entry or the model interface) and in figure 4 (project planner or scheduler):

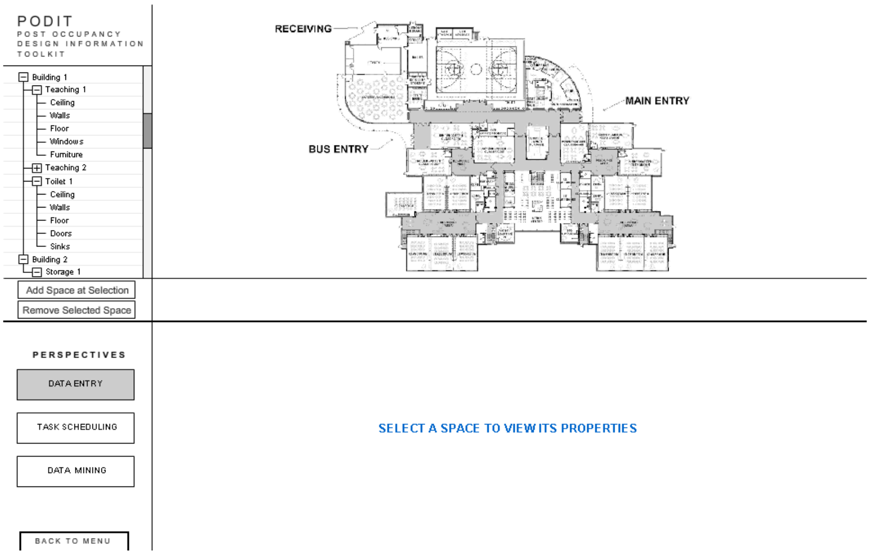

Figure 3: PODIT data entry interface

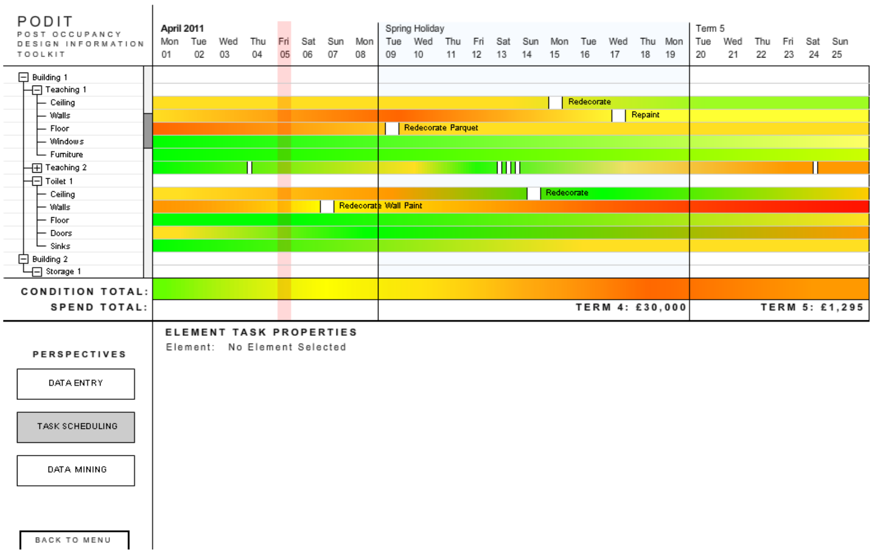

Figure 4: PODIT project planner (scheduler) interface

Third steering group was formed to gauge the response of the potential users to the application. A Demo was given and the members were asked to utilise and test different capabilities of the application and provide feedback. This was collected using a questionnaire to establish the function priorities as perceived and expected by the users, followed by a one-to-one semi-structured interview to monitor their needs and the software requirements in more depth. Some of the findings from this stage include:

- The traffic light system worked very well for visualising the outstanding tasks, jobs, etc.

- The scheduler interface was found very useful as it enabled the user to have a visual overview of the school project, the outstanding tasks and the overall condition of the building with break-downs to the level of buildings and spaces.
- The users liked the ability to navigate in the school model using a combination of visual (map) interface and datasheet (tree) interface being able to switch between the two.
- The need for the condition survey to become a live document (this was mentioned in both previous steering groups)
- Discrepancies between the ‘priority’ (1: immediate, 2: within 2 years, 3: within 5 years, 4: over 5 years) and the ‘condition’ (A: good, B: satisfactory, C: poor, D: bad) in the condition survey and the need to distinguish between them quite clearly to prevent further confusion for the user or clash between the proposed system and the current practice. There were some concerns about the time brackets for priority and the need for more accuracy.
- There were also concerns about sensitive data, the amount of work to initially launch the system and interests in data sharing between different parties as the same level or belonging to different levels.
- The budget interface was considered necessary, so was the job packages interface (these two were not developed, at this stage, to the same level of details of other interfaces, due to time restraints).
- Sorting function for the condition survey as well as the output format (spread sheets, .pdf files, etc.) were also highlighted as important to ensure that the system complies both with the legal and liability requirements, and also the current practice is fulfilled and can be succeeded in terms of timeliness, data-share, accuracy of the system.

5. Conclusion

This paper reported on the development of the first prototype of a decision support system and its test in the framework of this research project on post-occupancy decision processes in school projects. The collaborative processes were focused on so that the stakeholders can work together using this platform for co-creation of value and knowledge which can feed into the decision processes. This was then explained as to how it developed into an application which can facilitate the decision processes in post-occupancy decisions in school projects.

The feedback received at this stage of the project was very positive. There is still more work to do and improvements to make before the final prototype can be put forward for testing in the last steering group meeting. The feedback from the third steering group will be used to improve the different interfaces of the toolkit, and to add or amend some interfaces which will keep up with existing common practice and also accommodate new options to help improve on the usability and choice for different type of users based on their preferences, needs, requirements and specific tasks.

The next step for this project will be to use the comments, requirements and needs of the users through the feedback provided in the first toolkit demo to improve the appearance, functionality, intuitiveness, ease of use and navigation as well as to ensure that all the aspects required and highlighted in this meeting and previous meetings are fully met.

6. Acknowledgements

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User attitudes and preferences - a study for Water Efficiency in UK Homes

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Abstract

The efficient consumption and use of water in domestic buildings is vital for protecting water resources for the future. About half of the water put into supply by water companies in England is to meet domestic demand alone and the demand from this sector continuous to rise year on year. A critical analysis of the literature showed that a common factor or barrier to acting sustainably water-wise is the level of awareness of users as well as their willingness and ability to make the necessary change. A nationwide survey was therefore commissioned to further examine this premise and to further understand the propensity of households to change behaviour and adopt technology to save water.

The study found that majority of households and water users already have a positive attitude to using water efficiently. However, the knowledge and the resources to translate this to action e.g. through behaviour change or use of water saving technologies is lacking. This confirms that developing knowledge competency and adaptive capacity in water users is needed. This can be achieved by working with households to develop technological and behavioural strategies for water efficiency that fits with their preferences and lifestyles. The paper therefore concludes by recommending a 'diy' type tool to support households to implement water efficiency solutions in line with their social, physical, economic and environmental context and constraints.

Keywords: Attitudes and preferences, Behaviour change, Households and homes, Water efficiency.

1. Introduction

Water is a strategic and critical resource which some commentators have ascribed more importance to than some energy sources such as crude oil (Koehler, 2008; The Pacific Institute, 2009). The impact of climate change on energy supply is well documented. Similarly, some 20% of the increase in water scarcity in the coming decades will be caused by climate change (UN, 2006) and a 5^{o}C increase in temperature compared to 1999 levels is likely to expose hundreds of millions of people will to increased water stress (Stern, 2007). About 1.1 billion people around the globe already lack sufficient access to safe drinking water (UN, 2006). Water availability is also a challenge for developed countries such as the UK, where evidence shows considerable water stress in certain areas (EA, 2011). Although the Lake District is the wettest with average annual totals exceeding 2000 mm, all of East

Anglia, much of the midlands, eastern and north-eastern England, and parts of the south-east, receive less than 700 mm a year (UK Met Office, 2010). According to the UN Environmental Program, buildings consume 20% of the world's available water and this continues to increase. At present in the UK, about half the water put into supply is to meet household demand and the quantity of water used by households increased by up to 55% in the last 25 years (DEFRA, 2008) while household per capita consumption remains high at around 170litres per person per day in unmetered domestic properties (EA 2008). It is worth noting that this level of resource consumption in buildings can also be attributed to technological development, economic growth, demographic factors, institutional factors and cultural developments (Abrahamse et al. 2005).

Water efficiency, compared to water conservation, is the optimised use of water commensurate to need which is not based on objective indicators but subjective need. It is also about the essential and appropriate supply and use of the right amount and type of water for necessary functions/activities for which it is intended. Water efficiency is marginally different from water conservation in that it acknowledges essential water use. Therefore, water efficiency does not advocate the reduction of water consumption to the extent detrimental to consumer health or welfare. Instead, the strategy is to understand customer behaviour, activities and how this relates to water needs, by which it will be possible to reduce wasteful behaviour by increasing the knowledge and adaptive capacity of water users. The IPCC (2001) define adaptive capacity as 'the ability of an individual, processes or system to adjust to climate change in order to moderate potential damages, to take advantage of opportunities, or to cope with the consequences'. Knowledge competency is described a process where knowledge about specific customers is generated (Campbell, 2003) and applied for their use. Gibbbert *et al.* stated that this is when customers are emancipated from being passive recipients of products and services, to empowerment as knowledge partners (Gibbert et al, 2002). Herein is the challenge with promoting water efficiency in homes.

The changes to the UK building regulations - Part G (2010) and the voluntary Code for Sustainable Homes go some distance in setting an 'objective' target which influences building design, specification and delivery. However, water efficient behaviour cannot be guaranteed after the building is commissioned. If the expected levels of reduction in water consumption are to be achieved, water users will be required to adopt positive behaviour, modify habitual activities. To achieve this, the government, water companies and NGOs have embarked on a series of initiatives to increase awareness and to motivate and incentivise users. Current strategies include leaflet messages attached to water bills, in some cases, free or subsidised fittings and gadgets. This paper focuses on water users, not water customers or building clients, as the key custodians of water efficiency in buildings. It starts with a brief review of attitudes, perceptions and behaviour. It then discusses the research aim and the methodology utilised to achieve the research objectives. The data from the questionnaire survey is then presented, followed with a discussion of the findings and conclusion.

1.1 Perceptions, Attitudes and Preferences of water users

Behaviour is influenced by people's lifestyle, values and preferences. Although design and specification to water efficiency standards is a good start to reducing water consumption in buildings, behaviour change in water users and customers is essential to achieve sustained savings. Behaviour change is a *response* to attitude change where the individual has incorporated a personal view which directs behaviour through a sense of mastery and control that the individual attributes to the self rather than to an outside influence (McCalley, 2006). Gatersleben *et al.* (2010) proposed that a degree of ‘intermeshing needs to take place between people’s values and lifestyle and the environmental cause for acceptance to make change to occur. This intermeshing effect is directly linked to how the environment influences everyday life and the extent at which the general public would be more willing to participate in schemes and to lower consumption. It is also more likely to take place if the individual or group is directly affected and the cause is clearly identified. For this to occur, a good understanding of factors of importance to people, and a better understanding of what it is they want to achieve by adapting, is needed (Larson, 2010).

In addition to lifestyle preferences, population growth and household demographics have also been found to impact on water consumption patterns. In England, the South East in particular, the increase in population and the creation of urban conurbations and agglomerations due to the expansion of cities and commuter belts places a substantial amount of stress on water resources. The increasing trend of low occupancy households (Mitchell, 2001) has also been highlighted has an important factor for the management of water resources. Single occupancy households are particularly on the increase. This places additional stress on housing supply and has consequences for energy and water consumption as well. Single occupancy households appear to consume more water per person than larger households with two or more occupants (Ofwat, 2009).

In a previous study, Martin (2006) found that people’s lowest priorities for improvement among the public were ensuring a reliable water supply for homes, and industry, all year round. Dessai & Sims (2010) also found that people’s awareness of water shortages or their understanding of the impacts of climate change seems to have little bearing on their willingness to accept incentives to use less water. No statistically significant relationship was found between people noticing more water shortages and their willingness to pay more for water or to accept water restrictions to mitigate the effects of climate change. The recurring issue appears to be that public perception of water issues vary from the perception of policy makers, regulator and key industry players. According to Larson (2010) this dissociation may be corrected through the improved “translation” of policy goals and actions into issues relevant to people on the ground. This may play an important role in increasing understanding and consequent acceptance of the principles of sustainability and adaption.

The literature review also found that technological interventions e.g. improved plumbing, water products, fixtures and fittings, are a useful baseline for water efficiency in buildings. However, technological fixes alone is often enough (Uzzell, 2008), consumer attitudes and behaviour often affect the levels of savings achieved (DEFRA & CLG, 2007). However as Gilg & Barr (2006) observed, behaviour is difficult to influence. Better results are achieved if through engagement and participation, the individual’s adaptive capacity is improved, enabling them to make the choice to change. Another approach is to remove the barriers that limit the ability to act in a sustainable manner. If people seem to be acting in environmentally damaging ways it may be a product of their attitudes and behaviours, but it may also be a function of the conditions in which those attitudes and behaviours are formed (Uzzell, 2008).

2. Research methodology

The research question was whether the preferences and attitudes of water users in the UK affect water efficiency in the home. In addition to investigating perceptions, attitudes and priorities, the study also investigated dependant factors identified in literature, such as: user characteristics, building type and ownership, geographical location, level of awareness of water and environmental issues etc. Due to the nature and range of variables under study, a quantitative methodology using questionnaires was utilised. The survey respondents were randomly sampled from the database held by a market survey company. The survey was then disseminated online and email invitations sent. The survey was 'live' for one month only. Due the random nature of sampling, the questionnaire began with general questions about gender, age, type of accommodation, location of respondents etc. Responses to these questions helped to provide context for the data and aided interpretation and analysis. As discussed in the literature review, the second part of the questions attempted to group respondents based on their attitudes, perceptions, building type, and household composition linking these with behaviour and technological preferences. Data from the survey were inputted into a statistical analysis package for statistical and descriptive analysis.

This study is limited in the amount and spread of responses received. Although the findings are valid for achieving the objectives, a comprehensive longitudinal study is highly recommended to gain further and more in-depth understanding of the influences on water consumption behaviour.

2.1 Summary of findings

About 1000 respondents which were sampled randomly from the market survey company's database were contacted. 546 respondents started the survey, of which 393 fully completed it. User comments are presented in quotes.

The age profile of respondents was represented in 6 age bands: Ages 16-24 (10%), 25-34 (30%), 35-44 (23%), 45-54 (16%), and 55-64 (13%), 65+ (8%). The gender representations were almost equal with 49.1% female and 50.9% male. The UK was divided into 7 regions to identify the geographical location of respondents. Disproportionately, more than half (51%) live in the South East region, 29% in North England, 16% in the Midlands, 2% lived in Scotland, 2.5% in the South West and Wales, with 0% represented from Northern Ireland. Majority (34%) also lived in semi-detached houses, 27% in terraced houses, 23% in apartments/flats, 15% in detached houses, 1% in bungalows (mostly respondents aged 65+) and the remaining 1% in maisonettes. The occupancy profile was such that 56% lived in households of 1-2 people only, confirming findings in Ofwat (2009). 70% were home owners, 22% tenants and the rest occupied social housing, live with parents or in student accommodation. Only 9% live in single bedroom properties; of this percentage, more than 90% live in apartments. Majority (44%) live in 3 bedroom properties, predominantly semi-detached and terraced houses, 30% in 2 bedroom apartments or terraced houses and 17% in 4 bedroom detached or semi-detached houses. 66% of respondents only had one bathroom and 29% had two. Majority (77%) of detached houses had 3 sanitary rooms in one form or the other; bathroom, shower rooms, cloakrooms, wet rooms etc. As expected, all the dwellings have a kitchen.

"Living in a flat means we can't have a water meter. So there's little incentive that way to save water".

"I desperately want a water meter but the council says it's not possible due to the way my ex council house is built. This infuriates me as I had one at my previous property and it saved me a lot of money."

Lastly and importantly, 98% of respondents are directly responsible for paying water bills but 64% of the respondents do not have a water meter and therefore do not pay for water based on their consumption. Even though there was a general willingness to do so. This is because metering is not compulsory in most parts of the UK. A larger percentage of respondents in the South East had water meters; this is due to the large scale metering programme that is currently underway in this region.

2.1.1 Lifestyle and values

Respondents were asked to rate some lifestyle and value criteria on a scale of 1 to 10; 1 being highest and 10 the least priority. The 10 criteria were sourced from literature and are, in no particular order of importance: education, income and finance, health and wellbeing, family and friends, house and property value, technology and gadgets, national prosperity and welfare, neighbourhood and community, the natural environment and water – availability and quality. Figure 1 graphically shows the lifestyle and values priorities defined by the respondents.

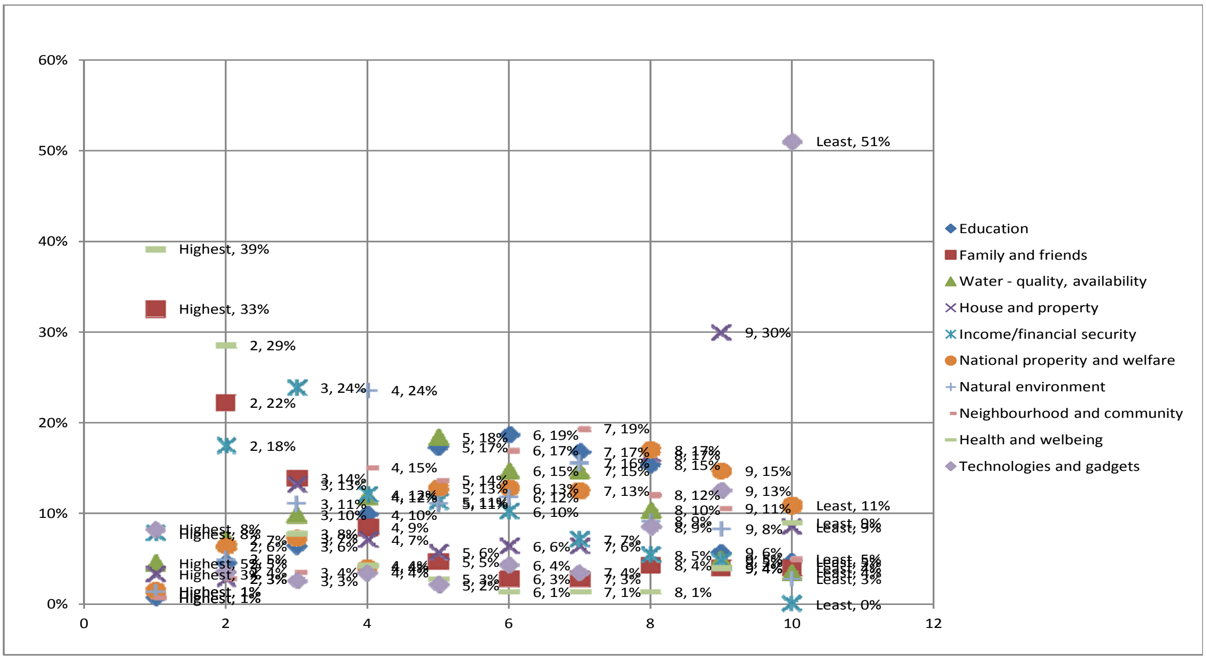

Figure 1: Respondents lifestyle and values

Figure 1 shows the highest ranking factor was Health and wellbeing at 39% - the highest scale of 1, followed by Family and friends at 33%. The least ranked factor by 51% on the lowest scale of 10 was technology and gadgets. Income and financial security was 3rd, Natural environment 4th, Water – availability and quality 5th, Education 6th, Neighbourhood and community was ranked 7th, national prosperity and welfare 8th and house and property value ranked 9th, by the majority of respondents. This finding suggests that public engagement and strategies that predominantly proposes technological solutions alone are likely to be ineffective. Water is mid-line on the list of priorities suggesting that water efficiency messages should reinforce the value of water in the context of health and wellbeing, reinforcing values of family and friendship, consolidating messages on climate change and the environment whilst emphasising opportunities to save money or protect income.

2.1.2 Awareness of water issues

There was no statistical significance or relationship between respondent's age or location and their level of awareness of water issues ($p = 0.476$ and 0.945). There was statistical significance between awareness of water issues and awareness of climate change/ environmental issues ($p < 0.001$). There was some variance in respondents' views when asked about their awareness of water issues in comparison to overall environmental issues. 23% said they had a low awareness of water issues compared with environmental issues (12%). However, those with average awareness were very close at 60% and 61% respectively. Also, 17% for water and 26% for the environment said they had a high awareness of the respective issues.

> "We're bombarded by suggestions of ways to save electricity but suggestions about saving water usage seem to have either been lost or slow to permeate".

The indication is that efforts at improving awareness of green matters have been moderately successfully (around 1 in 4 having a high awareness), but at the same time, there appears to still be low awareness of water issues by some respondents. This was also the case with respondents residing in areas that have recently experienced risk events such as floods and droughts and in spite of recent weather events internationally.

2.1.3 Attitude to saving water

There was some correlation between level of awareness and attitude of respondents on the need to save water. The question on attitude was structured on Uzzell's (2008) classification of those: "who would, could, can't, don't and won't". The important finding from this section of the study, irrespective of the level of awareness, was that 44% of respondents stated that they already conserve water but realise that they need to do more. They also needed to know more about how to go about doing this. This confirms the need for knowledge competence in water users which will ensure that information and awareness is translated into positive action.

> "I don't know a lot about water saving issues or the need to save water. I need to know more and need educating on the issues and the need to save water. I also don't understand all the technologies/equipment that are available for saving water and would need to know more so that I can make an informed decision. I'm not likely to undertake the research myself due to personal time constraints and higher priorities and so this information needs to be drawn to my attention. I'm generally keen on the idea of living a 'greener' life and so would adopt greener ways of living if they were presented. For example, our council introduced recycling and food waste recycling and I participate in it with enthusiasm".

Similar comments were received from many respondents. This suggests that awareness messages should be carefully designed and targeted in order to avoid a negative response as was evident in some respondents, even those with high level awareness. For this group, the next favourable responses were “I could but choose not to because there are more important things to focus on” or “I would but I don’t. I recognise the need to conserve water but I still don't do anything”. In addition, 24% said they couldn’t do anything more due to financial constraints.

> “I can't afford to upgrade dishwasher etc to water saving one until they break, too expensive to buy new ones”.

About 22% said they can’t because they are tenants and do not have the right or support of the landlord to make changes. Only 2% said their lifestyle would not permit them to make changes. This trend was repeated when attitudes were correlated with awareness of climate change issues.

2.1.4 Making changes to save water

Survey participants were asked what changes they will make in order to save water. On a scale of 1-3 (1 = high preference, 3 = low preference), respondents rated the three options; adapt behaviour, revise activity or adopt water efficient technology, based on personal preference and in the context of their household and lifestyle. Findings show a general preference by respondents towards to change of behaviour, ranked high by majority (55%) first, then to save water through revising or choosing alternate water saving activity (ranked medium by 47%), and last option (ranked low by a 53% majority) was to adopt new technologies or implement technological interventions.

> “I believe that saving water is not so much about using new advanced gadgets/devices - although some devices can help to some extent. The need is for a change in behaviour through transforming attitudes, perceptions and values”.

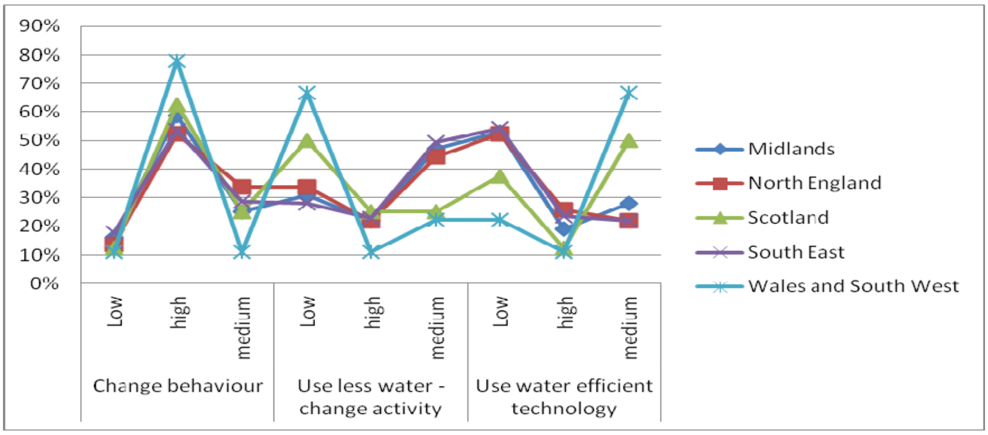

Figure 2: Preference for saving water based on location

This trend was similar irrespective of the level of awareness of the respondents to water issues or the respondent’s attitude to saving water. The trend was also similar when correlated with the respondents’ geographical location with the exception of the respondents from the South West and Wales, and Scotland, who ranked the use of technological intervention second and changing activity to save water third (Figure 2). Respondents living in bungalows also ranked technology second and were undecided about saving water through revising water consuming activities within the home.

2.1.5 Water efficiency technologies

With regards to the adoption of water saving technologies, it was important to first assess what water efficiency provisions already exist in the respondent's homes and what is being planned for the immediate 12 month period. A list of water current water saving technologies was provided and in a response matrix, respondents identified whether they; already have it, they plan to implement in the next 12 months, no plans to get, no plans to get but open to the idea or they need to know more.

Majority already had water efficient washing machines but there was a lot more spread with dishwashers; majority do not have plans to purchase or replace existing machines. The current strategy to give out free gadgets such as water hippos seem to have some support with 42% saying that they are open to the idea. Majority of those that have gardens said that they have a garden water butt. Also, 44% majority already have dual/low flush WCs. Majority of respondents do not have water efficient taps with 42% open to the idea but a further 29% do not plan to change their taps. Only 25% have water efficient showers, although, 38% said they were open to the idea. Interestingly, 15% said they have integrated some form of Sustainable Urban Drainage system (SUDS) in their hard paved areas. In general, 1 in 5 are 'open to the idea' of water saving technologies. Over a third of respondents already had a wide range of water saving technologies or products e.g. WC with low flush (44.06%), water butt (also 44.06%), water efficient washing machine (41.26%), in particular, the technologies that are simple, common, have been in the market some time and are easy to use.

However, a finding of note was the poor propensity of respondents to make the change to adopt water saving technologies in the short term. When asked if they plan to change to more efficient products/fittings in the next 12 months. The highest response at 9% was to change to water efficient WCs. Followed by water butts at 8% and dishwashers and waster saving showers at 7%. Recycling systems such as rainwater and grey water systems received a poor response in general and only 3% and 1% respectively said they will adopt these technologies in the short term. Even though 55-56% said they are open to the idea of water recycling. A longitudinal study is needed to further investigate medium to long term adoption.

2.1.6 Constraints to technological adoption

The majority of participants indicated that they considered water saving technologies of all varieties to be both good for the environment and a good way to save water. The constraint is therefore not the perception of the technologies or the lifestyle of respondents but the willingness and capacity to adopt them for use in their homes. It was therefore important to explore factors that affect the uptake of water saving technologies. From the data, 67% said cost was the most prohibitive factor for adopting water saving technologies.

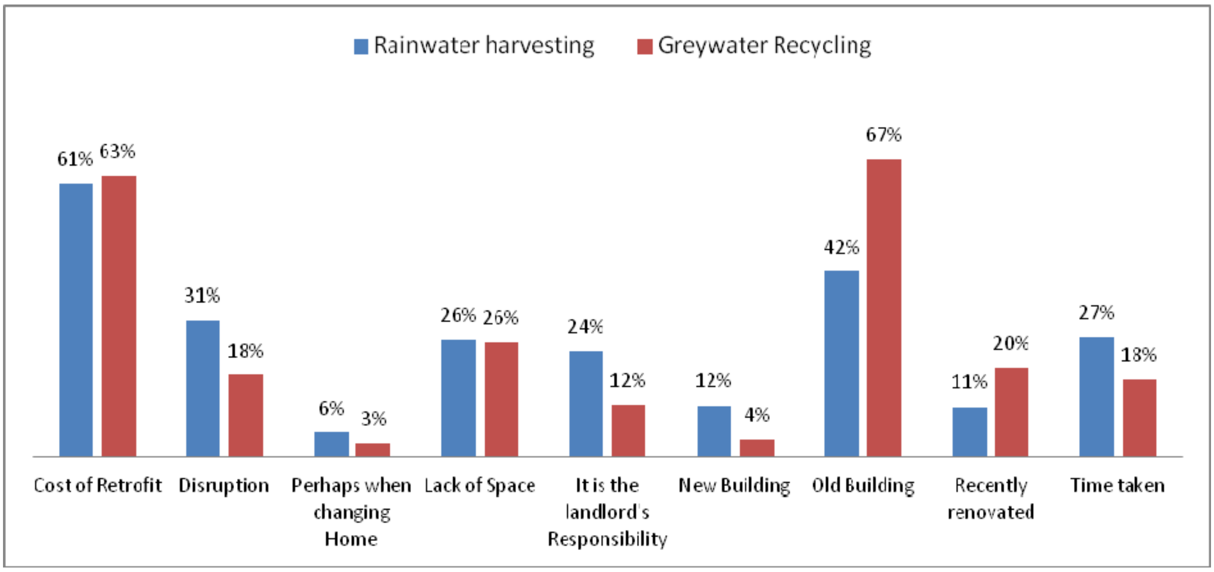

Figure 3: Constraints to water recycling in buildings

> "Further water saving equipment has prohibitive costs (i.e. rainwater harvesting) yet is very suitable to our lifestyle and household. Readily available grants or subsidies would help".

The age of the building was also important (Figure 3); especially if the building is too old or even too new. 42% said that old buildings are difficult to retrofit while 7% said that they live in new buildings and do not have the intention to start making changes in the nearest future. This tie in with the next three main constraints (at 31% each), which were space limitations, the amount of disruption and the time taken to retrofit water efficient features into an existing building. Even though 13% had recently renovated their building; some did not consider water efficient replacements. Nonetheless, this group of people would not make further changes to their property in the short term. 5% said that they will consider water efficiency when looking to change or move home and 20% said that water efficiency was the landlord's responsibility.

3. Discussion

The findings from the survey support the hypotheses that the attitude and perception of water users vary depending on their priorities, the opportunities and constraints of the property and their attitude towards water and water issues. This is in turn is influenced by the willingness to change, the capacity to change and the limitations of 'what is known'. Respondents' knowledge of water efficient technologies; information on the function, performance, effectiveness, cost, health risks etc were considered important for making decisions about whether to adopt a technology or not. But, majority of respondents will consider changing domestic activities to use less water and changing behaviour, before they consider water saving technologies. This suggests that techno-centric measures or initiatives will be less effective to domestic users who will rather engage with non-technological approaches. Also, diminished capacity to adopt was found for respondents that live in rented properties.

> “I would love to install a variety of water saving measures as I recognise the importance of conserving water. However since I live in a rented property I am unable to make decisions on plumbing and appliances”.

> “I would but I am a tenant and have next to no say in water saving measure implementation other than my own behavioural response”.

Majority of comments provided at the end of the survey implied a willingness to change or adopt new technologies but the lack of empowerment to do so. This suggests another area where targeted policy (e.g. during change of occupancy, currently done with metering) might be of benefit. Findings also suggest that some measures and initiatives that apply to existing buildings are required. There is a general perception that implementing water saving technologies in existing homes will be costly, disruptive, have impact on space etc. The lack of incentive to adopt new technologies to existing homes was also highlighted. Homeowners and building users will generally like to see efforts made to change behaviour, use less water and adopt technologies, reflected in water tariffs and bills. Lastly, from this limited study it was found that user perception is important but it not the most defining factor in changing water consumption behaviour, or whether households adopt water saving technologies. More important factors include the building type and constraints, building ownership – tenants in rented properties felt powerless to make the necessary changes, awareness of water issues, and cost of implementation.

4. Conclusion

A critical analysis of the literature showed that a common factor or barrier to acting sustainably water-wise is the level of awareness of user and their willingness and ability to make the necessary change. This study confirms the last two and further identifies that water efficiency messages should be presented in a manner that confirms or conforms to individual and household priorities and preferences. It was also found that a positive perception already exists in most people towards saving water and awareness was relatively high. The barrier is translating awareness and positive perception to a positive attitude which in turn will drive positive change. A start is to tailor the message such that domestic consumption relates with the bigger picture of water resource management, the environment and climate change. ‘Intermeshing’ needs to take place for pro-environmental behaviour to become less detached from everyday values. The best way to achieve this is through creating knowledge competence in water users, and co-creating value through better engagement and a flexible, customisable strategy. Technology needs to be robust and perform in line with user expectations and it should be deployed in such a manner that allows users to interact with them based on their lifestyle and needs.

Water efficiency strategies should provide support for both technology and behavioural change. The Building Regulations and the Code for Sustainable Homes predominantly focus on water efficient fixtures and fittings. Interlinking technological interventions and behavioural/activity change to propose a holistic solution in buildings is likely to be more beneficial for users. Therefore, the recommendation from this study is a ‘diy’ water efficiency tool for households. The tool should provide a simple and user friendly knowledge framework to help households implement water efficiency strategies based on their social preferences, physical, economic and financial context.

5. Acknowledgements

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How to Express Goals for Construction Projects

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Abstract

Many construction projects are started without stated goals that can be communicated among the stakeholders, design team, construction managers, and workers to enable them to understand the purpose of their efforts. In such cases the program, design, and execution of the work lack the guidance needed for making choices and assessing quality during the design and construction processes.The aim of this study is to find and analyze a number of projects that have formulated goals and used them successfully in support of project management. There are examples of projects that articulate values, specify objectives, and manage activities in order to fulfill the stated goals, breaking them down into brief documents and design parameters. A number of projects representing a variety of uses that were submitted for Sweden's national Building of the Year award have provided the basis for a study of the types of values and goals that were articulated for each project and how those goals were expressed. One was selected for a case study of how goals are formulated by the top management of a client/user organization and by employee representatives in the same organization. The formulated goals express demands on effectiveness for the user organization or business. They also concern the building object itself—its efficiency, energy use, identity, and design. Goals are established for the performance of the planning and construction processes, such as how the various actors will interact and collaborate. The most significant finding is that a predominant number of goals are not expressed in concrete, directly measurable terms but in softer, qualitative terms that have to be broken down into operative briefing documents and design parameters in a top-down approach. Nevertheless, these soft goals, although impossible to verify by measurement and numbers, are shown to have an evident steering effect on the projects.

Keywords: Construction management, Construction briefing, Design management, Expression of goals, Top-down approach, Empirical paper

1. Introduction

Most client organizations for construction projects have worked over the years to improve the product development processes by shortening lead times, conserving resources, reducing callbacks, and increasing reliability. Measures well established and continually taught in every sector of the construction industry (see, for example, research on lean construction). However, these measures all depend on knowing what is to be done— which means, that the details of the project are well known to all of the parties involved. But, for the client, the course of projects cannot be entirely foreseen. Some are outside the scope of the client's prior experience, therefore the rationalistic methods mentioned above do not always work. For the client to be able to control vaguely defined projects, good planning is not enough as projects also are accompanied by a degree of uncertainty. For the client, the challenge of developing a construction project includes making choices and decisions whose future consequences often cannot be entirely described in advance.

In this article we examine a number of successful projects in order to describe various methods for formulating and specifying project goals. Our survey of the goals and categories of goals given in the case descriptions is intended to provide an understanding of various kinds of goals. We have also studied which aspects of a project are prioritized in the planning process and what the basic conditions of the project are in relation to the operations and use of the building. Often it is a matter of going from ambiguity—from the difficulty of understanding the different elements of a project and the internal connections between them—to what is desirable (and possible) within the framework of the project, and understanding how the project's other stakeholders perceive and interpret the project (Spender and Kesser 1995). These situations are ambiguous. The purpose of this article is thus to advance our understanding of how clients identify, specify, communicate, and even reinterpret and further develop various kinds of goals in order to achieve a desired effect.

2. Front-end strategies of how to define construction projects - in theory

The method of systematically controlling the processes that shape a project from a comprehensive to a detailed level is known as top-down. The systematization is intended to successively break down comprehensive goals into operational goals for various subsystems. This approach ensures that the project is controlled and directed toward the purposes and goals established for the project. In the bottom-up method, on the other hand, defined subsystems are integrated into larger, cohesive systems. The project may be said to be synthesized by adding various component parts together to form a whole whose content could not have been foreseen from the start.

A top-down model (Bluyssen, 2009) can be described as a number of steps from comprehensive goals to completed project:

1	*Comprehensive project goals*
2	*Breakdown of comprehensive goals into demands and desires from a user perspective*

3	*Translation of demands and desires into technical terms*
4	*Experiments with concepts for technical solutions that can satisfy the stated demands and desires*
5	*Detailed system design production and marketing*
6	*Use and adaptation over time. Change*

This top-down model means that the diverse viewpoints of the client, end-users, tenants, and buyers can be incorporated into the process at an early stage and can be expressed in terms of goals. This method therefore demands that these stakeholders actually can and want to express themselves at an early stage in the kind of abstract terms that may be required. In many cases, however, end users don't express concrete opinions until the step 4"Experiment with concept…" or 5"Detailed system design…". The core of this approach is developing the stakeholders' understanding of the ambiguity of the task—building their awareness of the contents of the project, its various components, and how each component fits into a comprehensive context such as the market in which the client is active. A client can manage a project using the top-down method but, within the framework for a project controlled from the top, leave open opportunities for a series of changes and additions to accommodate requests from occupants or buyers. These requests can be brought forth through market research in the demographic groups targeted by the client. This might be called a combination of the top-down and bottom-up methods. In many projects that are controlled using the top-down method, one must periodically confirm that solutions for certain components truly are feasible before the project can move forward. That means going into detail to establish that certain technical demands really can be met.

Besides the need to combine the two methods described above, the strategies for formulating goals for construction projects may be further divided into two more dimensions. The first dimension refers to the product that the project is intended to result in—that is, what is to be developed, whom it is for, and why it is being built. The other dimension deals with the process of realizing the planned result—that is, how the client intends to proceed, which methods and tools the client will use, and which actors will be involved. An additional factor is the client's approach as to which goals need to be "frozen" or "locked in" with formal decisions before idea and theory are followed by action.

A planning model that proceeds from the comprehensive organizational level down to the definition of individual projects is called strategic programming (Blyth and Worthington). A strategic program or brief describes an organization or business' need for space in light of the changes it will undergo over time. The strategic brief must ensure that goals for individual projects are not in conflict with the organization's overall goals and business plan. From the planning conducted at the comprehensive organizational level, boundaries are established between individual projects in order to clearly articulate the purpose and goals of each one. The brief describes the goal of each project and the chosen strategic plan for realizing it. It describes the project's effect goals in operational terms, its priorities, its potential future changes, and the procedure for making decisions during the course of the project. The strategic brief is the basis of the project. It articulates the aspirational goals of a client's strategic business case for a project into a development strategy, whether for a single building or a merged program of interrelated projects. It is made as a part of the preparatory phase of developing and testing the feasibility of a project.

Project goals are further developments of an organization's strategic goals and define the individual project as a basis for its realization. In order to work as an effective roadmap for the work of the project, these goals should fulfil the following 5 criterias:1) A clear definition that is unique to the project, 2) Measurable by some method, whether numerically quantifiable or measurable through some form of questionnaire or evaluation, 3) Achievable with the available resources, 4) Time limited and 5) Communicable: so compellingly formulated that everyone involved in the project can understand and follow up on them.

3. Method

The focus of this study has been applications for Sweden's annual Building of the Year award that was handed out for the sixth time in 2011. A total of 154 presentations of projects have over time been submitted for evaluation and scrutinized by one of the authors of this paper who also was a jury member. In more than a third of the cases, the jury visited the site and conducted interviews that were documented. The application for the prize requires a presentation of the built project as well as a description of the process that led to the final result. Below are some examples of how various projects defined their goals, broke them down into sub-goals, and formulated the project demands. All of the projects represented here were deemed by the jury to be particularly qualified: each either won, was nominated or shortlisted for the prize. They represent a broad spectrum of project types. Furthermore formal documents and drawings from the projects as well as the final results and the process were reviewed.

4. Empirical results: goal definitions in 8 case studies

Considering how different project goals are formulated in practice this section reports finding from eight case studies.

4.1 Vänern House, Karlstad University:

Akademiska Hus' most important tenant category is universities. Their business concept is to be the leader in creative environments for higher education and research and is one of the the largest property companies in Sweden They have erected a building for Karlstad University that houses research and undergraduate educational facilities for natural and engineering sciences. The building encompasses about 16,000 square meters and was completed in 2008. The project won the 2009 Building of the Year award. The client describes the vision for the project as follows: "*A vision for a building that supports innovative teaching, a meeting place for science and for people, an arena in which society, business, and academia work together.*" This client's vision is congruent with that of its tenant, Karlstad University, as expressed in the document The University in the City: Vision 2010, released in 1999. It includes the assertion that: "*We want to see the university as an important part of a lively urban environment. We see the university of the future as an integrated part of a multi-functional urban landscape.*"

In the project documentation, vision and goals have been summarized using a few keywords: *1)"The open university and the university in the city: the building shall contribute to giving the area an increasingly urban character. […] The design shall create the conditions for collaboration between the university and the business community." 2) "Teaching: the university strives for innovative forms of teaching in which the physical environment is designed to facilitate the learning process. […] The building shall have a flexible design and shall test new ideas that are generated in the process." 3) "Interdisciplinary science: the building shall stimulate collaboration across subject boundaries and between undergraduate education and research."*

These three overall vision and goal statements are expressions for the effect the building project is to have on the university. The following two goal statements are to some extent related to that broad effect, but mostly they are derived from the narrower effect goals of the building project: *"Architecture: the facility shall be a characteristic building for the university that reflects its high ambitions for education and research in the technological and engineering sciences."* And *"the buildings shall be designed and constructed based on principles for sustainable development."*

In the programming work conducted in collaboration among the stakeholders, the given comprehensive goals were concretized and broken down into tangible sub-goals for the planning process: *"In educational workshops…theory is tied to practical action learning. This type of teaching requires more group spaces and laboratories than traditional teaching*." And "*The new teaching requires more group spaces and studios, although at certain times of year there is a great demand for classrooms."* This sub-goal required optimization and flexibility in the use of space—factors that came to be identified as quantifiable sub-goals as the differentiation of goals became more detailed. These sub-goals included the requirement that every space have dual functionality. Thus, a lecture hall was to be convertible into a group workspace and a workshop into an exhibition space. This in turn affected the demands on the interiors, equipment, and mechanical services specified in the operations-based technical program. The interdisciplinary goal gave rise to demands for places for teachers, researchers, and students to meet across subject boundaries. This was achieved in the project by reducing the area assigned to offices and workrooms for teachers. The change led to protests from various staff groups. As a result, the project included functional studies for faculty offices and workrooms.

Thus the definition of goals could not be managed entirely by the top-down model without conflict. The functional studies that were undertaken of various office units provided the basis for decisions about which of the functional demands were truly justified. This can be seen as an example of applying a complementary bottom-up model in the planning process. Another example of how the bottom-up method was used in selecting technical demands is the installation of an occupancy-sensor controlled air diffuser that reduced the flow of conditioned air and the energy use in accordance with the overall goal of sustainable development. This air diffuser was not developed specifically for the project, but was a component already on the market that was deemed appropriate to the specific demands of the project. If this technical solution had not been readily available, the demand for occupancy-sensor control would not likely have arisen.

The vision for an open university resulted in sub-goals such as the brief's demand for a zoned division of the facilities—a public zone where visitors meet with students in experimental workshops, laboratories, and exhibitions; a semi-private zone comprising student workstations and classrooms; and a private zone primarily reserved for staff workstations. The comprehensive goals have been translated by the architect into architectural design rules that cover aesthetic qualities, the design of meeting places, openness in the layout and interconnections of the plan, and adaptability, generality, and flexibility.

4.2 Ugglan Preschool in Alby

The Ugglan Preschool lies in Alby, in the municipality of Botkyrka, in a development built during the boom in mass-produced housing of the 1970s. It was constructed after the original preschool on the same site was burned down. The scope of the project was the construction of an entirely new preschool. The municipality initiated the project with a discussion of its educational vision for school construction, with special emphasis on preschools. The educational vision included the statement that *"In today's society there is a need for a preschool in which the foundations for life-long learning are carefully and meticulously established. Therefore it is important that the preschool can function as an arena for playful and experimental learning where children are offered new experiences that stimulate play and movement. The focus shall be on children and their development."* One of the sources for these ideas is the so-called Reggio-Emilia Approach. It provided an important foundation for the municipality's planning for its school construction in the form of a strategic brief. Ugglan Preschool was the first project executed according to the new brief. The educational vision was also tied to Vision 2020 for Alby, the municipality's vision for revitalizing the mass housing development with additional construction. Its aim is for the design of any new construction in the area to contrast with the large-scale, orthogonal pattern that dominates the built environment there. The project goals were established based on the given strategic briefing conditions, which prescribed "*a building with a character of its own, not institutional*" that "*must comply with Vision 2020 for Alby.*" Other project goals covered: Logistics; Long-term and future use; Security; Property management; Environment and energy; and; Exploitation of the property grounds plus connection to the existing city park

4.3 Halmstad Arena:

The Halmstad Arena project encompasses the development of a multi-use arena in Sannarp, an area reserved in the zoning plan for athletic purposes. Before the project, the municipality had already established what they called a strategy plan for the area: "*It designates planned and desired development and a transformation of the Sannarp athletic area.*" The basic ideas of the strategy plan were: "*The area shall function as a sports and leisure area serving primarily the municipality's clubs and the general public*." And "*Flexibility, security, good logistics, and fun are keywords that shall characterize the area."*

A comprehensive space-planning brief for the arena building was developed by the municipality in close collaboration with the clubs and organizations that were identified as stakeholders in the project. A number of goals were established for the project, in part as guidelines for the design and construction of the arena and in part to regulate the municipality's relationship to the developer chosen to build it.

For the product they established a number of goals: *"We shall satisfy the building's visitors; We shall employ life-cycle thinking; We shall give the Halmstad Arena an identity; We shall create a flexible facility for the future; Halmstad Arena shall be accessible to all*" The process was to be guided by the following goals: "*We shall work openly and with pride to establish trust among ourselves; We shall encourage participation and engagement ; We shall have a clear structure in our organization and processes; We shall maintain the agreed time schedules"* For the cost: *"We shall work within the established budget."* For the construction process*: "The goal for each party is to achieve the right quality with no faults by the final inspection."* These goals were to be followed up and evaluated continually, and concretized throughout the entire process through workshops, steering committee meetings, and a partners' council. In preparation for tendering among prospective developers, space planning and building programming issues were summarized in a brief that the municipality called a framework program. It was assumed that portions of this program could be changed as the final requirements were established. Decisions regarding the specification of program information were made by the board of directors, and the conditions for altering the program were agreed in the partners' council.

4.4 Sandgrund Park in Karlstad:

The idea of developing a new park in Karlstad emerged from a city council motion for a *"garden of the senses—a garden for all."* The concept was to create park in the heart of the city where even the physically disabled and the elderly would have a chance to get out into nature. It was even to be seen as a public health initiative. After a political discussion, the council agreed on a site for the new park: Sandgrund, the peninsula that divides the Klara River into two streams. A working group established the following elements for the brief: *"Accessibility for all; Cultural and sensory experiences; Distinctiveness and positive attraction; Year-round aspects; Concrete contacts with water; Areas for public activities; Operations and maintenance aspects*"

Based on the political vision and these elements of the brief, Torbjörn Andersson, the internationally renowned landscape architect hired for the project, developed a design program with four fundamental concepts: 1) "*A green central portion with fun-filled environments that also offer a wealth of experiences;* 2) *An active periphery along the shoreline affording contact with the water, places, and walking paths;* 3) *A stylistic adaptation and development of the museum environment in the area*…and 4) *A dramatic design of the tip of the peninsula with sculptural elements and night-time effects*" However, the main ideas for the design work were solidified in fourteen different design points. These were reworked several times together with the working group and other actors. The landscape architect has an interesting attitude to the verbally formulated goals and the written brief: "*In a way, I write my solutions before I draw them. This is a good method of designing: to describe it in words before you start sketching. Especially when you're striving, as I am, to achieve a strong concept. This kind of writing has a decisive advantage over sketching. Sketching easily becomes problem solving. Writing advances ideas…"* (Arkitekten, April 2010).

4.5 ABB Test Hall in Ludvika:

ABB’s test hall makes possible the testing and development of energy-efficient, environmentally friendly electrical power transmission systems. The building itself is an integrated part of the production system, and was developed as a unique project for which there were no precedents or standard solutions. The test hall is used for product development, testing of models and routines for devices that work with extremely high voltages—up to 2000 kV. The brief for the building was based on demands and performance. One important and completely decisive factor for the project was the need for protection from electrical disturbances. It was not known how this isolation could be achieved at the time the project began. The project schedule was driven by the demanding conditions of a contract with China, which led to an extremely tight schedule for the construction project.

The vision and the overall goal were for ABB “*to create the world’s best test hall*.” Moreover, the following project goals were established*:* 1) “Collaboration and working method: *“Through openness and trust, clear communication, and a constructive and productive climate of collaboration, proudly facilitate a historic technical leap for ABB*.” 2) Quality and working environment: “*Deliver the agreed quality and functionality…without accidents occurring in the workplace.”* 3) Time and cost: “*Complete the test hall by December 20, 2008 for a cost not to exceed the established budget”*

The difficulty of achieving the required protection from electrical disturbances resulted in this issue being treated separately from the rest of the project. It might be said that they dealt with it according to the bottom-up model. The whole project depended on a single conceptual solution. Once this solution had been found, the project could be managed top-down through demand specifications and design work. The deadline for the completion of the building was also decisive for the execution of the whole project as a business venture. As a result, the client gave the builder a bonus for completing the construction early.

4.6 Kungsbrohuset in Stockholm:

Kungsbrohuset is adjacent to the rail yard of Stockholm’s Central Station. An office building from the early 1980s was demolished to make way for the new project. In their application for the Building of the Year Award, the client, Jernhusen, wrote of the initial phase of the project: “*The year was 2007. Al Gore’s film An Inconvenient Truth had just won an Oscar and the issue of climate change was in focus. As a public property owner, therefore, we wanted to lead the way and demonstrate that you can actually build energy-efficient large office buildings without having to research or test unknown solutions. […] We simply wanted to see how far we could go with the existing technology and using several different environmental certification systems. We made an early decision to at least cut our energy use for the building in half compared to what was required by code*.”

“We didn’t want to get stuck with a finished building that would need to be renovated right away. We therefore sat down and wrote a very thorough brief for the building. In it we described all of our expectations for both the product and the process—the technical performance standards for the mechanical system, our thoughts on spatial efficiency…how we value quality, architecture, and

everything else that affects the process and the product. […] In order to be really comprehensive, we spent four or five months."

Apart from the goals for the building itself, goals were also established at an early planning stage for the project's impact on the urban environment of the affected area in consultation with Stockholm's city planning department: 1) "*…increase the density of Stockholm's central districts"; 2)* "*The entire project is one step in the plans by the City of Stockholm and Jernhusen by building unite Kungsholmen and the central business district.*" 3) *"…commercial spaces at ground level to increase street life."* The client also formulated the following vision: *"Our vision is to create a smart building with smart, environmentally friendly solutions. Those solutions shall be modern and proven technical solutions that are easily understood and user-friendly. The building shall have a modern, exciting, and an architecture that gets attention. It shall be a leading edge, verastile building with freedom of choice in the division of space and the selection of materials, and with technical systems that uncompromisingly support flexibility."* The overall goals were listed as: "*Create an urban architecture that puts this area on the map; Create flexibility for both tenants and property owners; Optimize leasable space through efficient planning, concentration of plumbing and ducts; Give the area a clear urban character; Plan for the future in terms of sustainability, environment, and climate issues. Think from a life cycle perspective."*

The environmental goals were formulated by stating that the building should conform to three separate environmental classification systems: two Swedish and the international Green Building system. Key figures for dimensioning the building were indicated in the following manner: *"A typical plan with 30% offices and 70% open plan results in a key figure of approximately 18-20 m2 per person."* Another example is the requirement that there be *"a maximum of 4 different tenants per floor."*

The client, Jernhusen, describes Kungsbrohuset as a pilot project for its model for defining a project using goal definition and careful briefing. The company asserts that their experience of projects in which this approach was employed indicates that the results were significantly more reliable and the projects easier to manage.

4.7 Emergency and Infectious Diseases Unit at Skåne University Hospital in Malmö:

After a strategic briefing initiative for the medical district in Malmö, the county council committed to bringing all of its hospital's emergency care facilities together in the same location (including emergency care, pediatric emergency care, and the so-called Referral Clinic) and to relocating the Infectious Diseases Unit to be directly adjacent to the emergency facilities. The Infectious Diseases Unit is the largest of its kind in Sweden. It has been located and planned in accordance with the goals summarized in the catchphrase *"Close but far away."* The closeness refers to its location directly adjacent to the emergency room with the opportunity to quickly isolate contagious patients. Far away refers to the space planning and air conditioning technology that limits the risk for contagion. This requirement has led to the development of an advanced air conditioning system with different pressure zones, and sluice functions between staff and patient areas. The Infectious Diseases Unit's cylindrical building volume has outdoor balcony walkways that provide natural air changes that help minimize the risk for contagion.

The projects overall purpose and goals are summarized by the client, Regionservice, as follows: *“Modern, efficient, secure, and competent care; Safe and comfortable for the patient; Rational and inspiring workplace for the staff; Space for education and advanced research ; A hospital that promotes health in a sustainable urban environment”* To help in the task of transforming these goals into requirements for the building brief and how to facilitate collaboration, a project handbook was produced. Different workgroups were started in order to formulate descriptions of the desired working routines based on the goals. New practices were described and standards of care were established as a basis for the job of writing a detailed building program.

Goals were established for the process of designing and constructing the building: *“Reduce the total project time by overlapping the design and construction processes as much as possible.; Allow the general contractor and subcontractors to advise the client and design consultants throughout the design phase to ensure cost-effective solutions without jeopardizing quality.; Maintain a high degree of flexibility in the execution in order to take advantage of the latest research, for example in the field of medical technology.”* During interviews hospital representatives also spoke generally about having adopted the working method of using building planning as a means to improve their organizational operations.

4.8 Postal Service Headquarters

The corporate CEO saw the project for a new main headquarters building for the Swedish Postal Service as an important step toward transforming the traditional postal organization into a modern, competitive transportation business. In dialogue with members of the board of directors for the corporate division responsible for facility planning, the CEO formulated the goals for the project as follows: 1) *“Relocating to the Post property in Solna should contribute to giving the postal corporation’s new headquarters an identity that is perceived as a consolidated and friendly Postal City;* 2) *The design of the headquarters in relation to the Tomteboda postal terminal, one of the largest production facilities in the corporation, should be planned with particular care and in a way that expresses the kinship between the two;* 3) *The area is to be given a campus character in which one moves between building volumes, each of which has its own individual character within the framework of a fundamental design theme;* 4) *The buildings shall harmonize with the landscape by accommodating the area’s character of a wooded slope and by preserving trees and other natural elements;* 5) *The area shall have a clearly marked entrance with good accessibility. To enable this, well-dimensioned parking facilities shall be provided for both visitors and employees;* 6) *The disposition of space within the headquarters shall be such that it gives the impression of being open and at the same time coherent in terms of internal communications;* 7) *The design of the facility and the surrounding area shall contribute to the well-being of those who work at the headquarters;* 8)*The disposition of space shall be cost-effective and thereby result in a reasonable leasing cost for the headquarters function;* 9)*The buildings and facilities of the Postal Service’s headquarters shall provide an effective support for its business operations by allowing for quick adaptation to changes in working methods and organization.;*

It is possible for the users of a facility to have a strong influence on a project if they are allowed to participate in the formulation of the project goals from the start. They may contribute to a number of different aspects of the project's contents by forming focus groups that work with various sub-issues. But they may also be involved in determining the overall scope and content of the project. In advance of the planning and construction of the Postal Service's headquarters, a staff group was formed at a very early stage. The staff group was composed of five young employees, all of them trainees in different departments and business areas within the headquarters. They were to report to the executive committee for the project.

*"*As an axiomatic point of departure, the group adopted the following thesis: *"The foremost goals for how the facilities are designed are: create total mobility and flexibility; increase the communication and understanding between different parts of the company; break down the hierarchy. Ultimately this contributes to strengthening the competitiveness of the Postal Service."* The group presented a discussion about open offices versus office cells, with the pros and cons of each for the Postal Service headquarters, and through that discussion took a position in favor of open office spaces: *"We advocate the open landscape. With that decision comes a great challenge, and that is to find the optimal balance between openness and privacy."*

The two sets of goals are not essentially different from one another. The CEO's points were based on a metaphor he used in his description, comparing the headquarters area to a university campus. This said something about an environment with buildings in a park-like or natural setting, and something about the intellectual, academic attitude he strove to implement with the headquarters as a centre of innovation and development in the field of transportation. The trainees developed and operationalized their interpretation of the concept of satisfaction introduced by the CEO. The trainees pushed hard for breaking down the corporate hierarchy with strategies like open offices. The CEO was concerned about the image projected by the Postal Service.These two parallel stories formed the basis for the project goals, and had a profound influence on the programming work and how the designers perceived their assignment.

5. Discussion

In the cases studied, few goals have been formulated that can be measured directly. It is possible in cases that involve energy use (like Kungsbrohuset) and time (like ABB's test hall). An example of a quantifiable economic factor in a goal statement is Halmstad Arena's goal of "maintaining the budget." In the case of the Postal Service headquarters, cost-effectiveness is inscribed in the goal for "cost-effective space planning."

A general conclusion that can be drawn from these cases is how one can use a story as the basis for specifying goals—goals that capture the essential content of the story and the teller's conceptions about the future. It is obvious that these conceptions cannot always be captured naturally in completely quantifiable terms. Instead, these goals are for the most part qualitative. This relationship can be explained by the fact that the goals for a construction project are tied to the goals for an organization or a business plan. As a rule, such goals are formulated not in entirely quantifiable terms, but in order to give direction for development and the ambitions of the organization’s leaders. We must in all likelihood conclude that the comprehensive goals for construction projects will most often be expressed in terms that are not directly quantifiable. If we were to accept only fully quantifiable goals, we would probably bypass a number of important factors that must guide the course of a construction project. The client actively contributes to the creation of a common “inner image”—a comprehensive understanding—of the project among its various stakeholders by actively creating meaning through early action, involvement of clients and users, and the use of prototypes and other examples. What distinguishes design problems and differentiates them from other types of problems is that they cannot always be defined in advance of the problem-solving process. Instead, it is only during that process they become clear. The client’s design problems are complex and can be ranked hierarchically, with comprehensive problems being defined more vaguely and subsidiary problems defined with greater precision.

6. Conclusions

All of the projects studied followed the top-down model in every important aspect, with the exception of ABB’s test hall in Ludvika and Vänern House in Karlstad, where specific solutions were developed with the help of the bottom-up model. Only a few of the stated goals are directly measurable in numeric terms during the course of design and construction. Several of them can be measured through various surveys following the building’s completion of the project. But to achieve measurability during the course of the project, most of the goals must be operationalized and measured as lower-level goals or requirements. Summing up, the main categories under which goals have been formulated in all the projects submitted for the Building of the Year Award during the last seven years were*: 1) Architectural quality, 1) Urban planning quality, 3) Energy use Conservation, 4) Accessibility, 5) Function, 6) Durability, 7) Environment, 8) Work environment, 9) Social relations, 10) Cost*, as categories of goals for the product. Furthermore, there were also categories of goals for the process. Such as: *A) Collaboration, B) Time, C) Planning, D) Quality control, E) Information, communications, F) Cost control, G) User influence, H) Programming, I) Bidding and negotiations, and J) Risk management.*

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A study of briefing practices and its effect on the quality of brief documents and client/end-user satisfaction in constructed health care facilities

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Abstract

The paper evaluates briefing practices and its implications for the quality of brief documents and client/end-user satisfaction in constructed health facilities in South Africa. The paper examines whether there is a relationship between briefing practices, quality of brief documents and client/end-user satisfaction in constructed health care facilities. The rational for the examination stems from the view held by scholars that the briefing process is critical to the success of projects as well as client/user satisfaction in the constructed facility, and also undocumented reports of client/end-user dissatisfaction in constructed health care facilities in South Africa. The paper employs theoretical perspectives in arguing that there is a relationship between briefing practices and the quality of the brief documents produced for the construction of health facilities. The paper develops a theoretical framework for use in validating the concept that the quality of brief documents and the level of client/end-user satisfaction in constructed health care facilities are related to the briefing practice.

Key Words: Brief, Client, End-user, Health Facility, Quality and Satisfaction

1. Introduction

The term briefing as it is commonly known, refers to the process of capturing and processing client requirements and translating these into attributes expected of a building to be constructed on behalf of the client (Yu et al., 2007; Yu et al., 2006; Shen and Chung, 2006; Ryd, 2004; and Bowen et al., 1999). According to Ryd (2004), the result of construction briefing can be regarded both as a product (the brief) and as a process (the briefing). Kelly and Duerk (2002) defined the process on a much broader level as the process of gathering, analyzing and synthesizing information needed in the building process in order to inform decision-making and implementation. The same process is referred to as architectural programming in the USA (Yu et al., 2006) and concept briefing adopted by MacPherson et al. (1992) in the UK for the same practice. Irrespective of the specific terminology used, process briefing is generally understood to be the process of eliciting client requirements in the construction industry. For the purposes of this study, the term briefing will be used exclusively.

The briefing process is widely considered to be critical to the success of projects (Yu et al., 2007) as well as in satisfying client/customer needs (Duerk, 1993 cited in Yu et al., 2007), however there is a broad consensus in the industry that current briefing practices are inadequate and fall short of delivering the intended output of a systematic identification of client requirements (Yu et al., 2007; Shen and Chung, 2006, Kamara et al 2000, Barrett et al., 1999). According to Yu et al. (2005a) a good project brief protects the client from major delays and will allow the design to develop more efficiently with the project suffering less slippage, rejections by the client and false starts.

The focus of numerous studies has been exactly around how the briefing process should be implemented, as this seems to hold the key to successful briefing. Yu et al. (2005a), Kamara et al. (2001), Shen & Chung (2006), MacPherson et al. (1992) identified the following shortcomings with the briefing process: format or lack of format of client brief with a heavy reliance placed on verbal briefing sessions; client body not being experienced; lack of comprehensive representation of all client bodies in the briefing process; identification and prioritization of client requirements being neglected; and lack of adequate time being allocated to the briefing process by the client desirous to have an early start on site.

MacPherson et al. (1992) noted that the briefing process is exceptionally complex in nature and even more so in the case of, what they classified as, non-standard buildings such as hospitals. According to De Jager et al. (2009) preparation of briefs for hospital buildings lie beyond the scope of the standard services provided by architects and other built environment professionals. In the South African health sector, several initiatives have been taken to guide the briefing process and this is reflected in the number of design guides that have been developed over the years for the design of health facilities. These design guides include the South African Hospital Norms (SAH Norms) (1992) - specifically developed for public hospitals in South Africa; the R158 Regulations (Dept. of Health and Dept. of Road and Public Works, 1999) – a specific design guide for private health facilities; and the Western Cape Norms document. The fact that the National Department of Health in South Africa has made the effort of documenting a briefing template is commendable, however this document is completely silent on how the briefing process should be implemented.

Undocumented evidence exists that there are large gaps in the health-planning sector of public hospitals pertaining to requirement capturing and norms guiding the design process. The absence of current planning norms leads to the design team relying largely on individual experience and generalized best practice in the planning process. It is evident that the briefs produced though conforming to specific guiding requirements and templates, fail to comprehensively capture client/end-user requirements which results in underutilization of spaces in the constructed facility, poor quality projects with building alterations being requested for relatively new hospitals and client and end user dissatisfaction. Lindahl and Ryd (2007) pointed out that it is difficult to deliver what user-client need, in construction projects.

Further, no empirical studies or results have been published on the briefing practices prevalent in South Africa, the content and quality of the briefs dealing with health care spaces or the level of client and end-user satisfaction in health care facilities. In addition, Abbott et al. (2008) noted that life cycle costing and analysis for South African buildings generally, and health-care facilities in particular is poorly researched and understood. According to De Jager et al. (2009), construction and design technologies and methods are unlikely to be transformed through this process of analysis into better healing environments, unless the information described in the briefing documents is systematically evaluated and validated against actual building performance.

The paper presents part of on-going research into briefing practices prevalent in the South African public health sector with reference to hospital buildings. The aim of the research is to examine whether there is a relationship between briefing practices, quality of brief documents and client/end-user satisfaction in constructed health care facilities. The paper first of all presents a review of the briefing practices in use holistically and within South Africa; secondly determines from literature client requirements, the indicators of quality health brief documents and measurements of client/end-user satisfaction; and finally it develops a theoretical framework that can be used in validating the concept that the quality of brief documents and the level of client/end-user satisfaction in constructed health care facilities are related to the briefing practice.

2. Overview of Briefing Practices in Use

The construction industry by its nature presupposes that the services of an external body are solicited to deliver infrastructure on behalf of a client, that the client requirements have to be elicited (briefing), and translated into design solutions that represent these requirements. A number of international studies assessing current briefing practices have been undertaken. In South Africa, papers by Bowen et al. (1999) and Nkado & Mbachu (2002) examined briefing practices within the general construction context, whilst De Jager et al. (2009) specifically assessed briefing practices pertaining to the construction of public hospitals.

Briefing practices for particular projects may differ depending on a number of variables pertaining to client type, building type and project type (De Jager et al., 2009; Shen and Chung, 2006; Bowen et al., 1999; and Latham, 1994). The client type which can be categorized according to three parameters: size – small or large; sector – public or private; and project interest – developer or owner occupant is perceived to have a great influence on how the briefing process for a particular project is approached and implemented. De Jager et al., (2009) noted that there are two basic distinct conceptions of briefing documents: one which considers the brief to be a finite thing which should be frozen and another which regards the brief as a dynamic document involving ongoing evolution throughout the building lifecycle.

Buildings can be classified as standard and non-standard buildings depending on the inherent nature of the structure for example; a simple warehouse would be considered a standard building whilst a hospital is considered a non-standard building (MacPherson et al., 1992). The highly specialist needs of the health sector and the divergence of priorities and services within the sector adds more intricacy to an already complex process (De Jager et al., 2009 and MacPherson et al., 1999). MacPherson et al., (1999) noted that clients of large projects are more involved in the decision making process and require tighter control on the project, whilst clients of smaller projects leave the decision making process at the discretion of the architect.

2.1 Briefing Framework and Phases

According to Kamara et al., (2001), current briefing frameworks deal with the elicitation of information for project planning from a project requirement perspective and to a lesser degree from a client perspective. Yu et al., (2007) noted that a comprehensive briefing framework should facilitate systematic identification and processing of requirements as well as precise and explicit representation of these requirements in documented form. De Jager et al., (2009) opined that the South African approach to briefing is ad hoc, as described, with some inclination toward the finite (as opposed to dynamic) approach as evidenced in the document, Annexure 7: Brief and Operational Narrative Framework 2009-2010.

It has been found out that the brief is communicated through the following media: oral/verbal presentation (Bowen et al., 1999; and Yu et al., 2007) - which is less structured and formal; and common among small and public sector clients. The study conducted by Yu et al., (2007) indicates that in the public sector, brief is developed in written format 58% of the time and often in a combination of written and verbal format. MacPherson et al., (1992) found that some large client organizations might have standard guides that may contain information pertaining to the briefing process and procedures adopted by this particular organization.

De Jager et al. (2009) citing the RIBA Plan of Work noted that a brief is normally developed in three phases. In the first phase, the client establishes the need for the project objectives. In the second phase, the strategic brief is enriched with sufficient information for consultants to commence the design process. In the third phase, the project brief is developed from the strategic brief in parallel with outline design proposals and detailed proposals. De Jager et al., (2009) noted that at this stage, the brief is frozen.

2.2 Briefing Practices

Latham (1994) and Kamara et al. (2001) suggest that briefing has eight stages: strategic analysis, client analysis, facilities analysis, statement of needs, confirmation of needs, functional brief, concept design and scheme design. However, Shen and Chung (2006) noted that these stages are not fully implemented in the Hong Kong construction industry. While Shen and Chung (2006) found out that the procedures for briefing in the public and private sectors are quite similar and that the brief is normally comprised of three stages only (also De Jager et al., 2009) – statement of need/functional brief, concept design and scheme design, Yu et al (2007) and Ryd (2004) determined that briefing has two distinct stages: Strategic Briefing and Project Briefing.

The Strategic Briefing stage is where the client’s needs, objectives and requirements are identified and clarified concerning a construction project, or projects, and the decision to proceed can be made accordingly, while the project briefing stage focuses on delivering the technical project – that is the construction industry’s response to client requirements expressed in the strategic brief. According to Yu et al. (2007), the project brief translates the strategic brief into construction terms, specifying performance requirements for each of the elements of the project.

Shen and Chung (2006) established that in the private sector, the brief process is informal and briefing is mainly undertaken by external consultancies, given either in a written or verbal format or through a combination of written and verbal format, and generally starts from the functional brief and followed by a concept design or scheme design. It emerged from the study by Shen and Chung (2006) that in the public sector, the brief usually starts with a statement of need and is followed by the concept design and scheme design, and that it is mainly undertaken by the central management unit, which specifically manages the brief of all the projects in a department.

3. People Involved in the Briefing Process

MacPherson et al., (1992) opined that the nature of briefing process requires the involvement of a number of key role players – stakeholders, clients, end-users and briefing consultants. According to Kelly and Duerk (2002), from the client perspective, a distinction needs to be made between stakeholders and decision makers in order to successfully manage each entity’s influences and expectations.

According to Yu et al., (2007) Primary stakeholders have a legal contractual relationship to the project and includes the project owner, suppliers, functional groups, investors and those from the public domain (such as communities and institutions) that provide infrastructures and markets, whose laws and regulations must be obeyed. Secondary stakeholders were identified by Pinto (1998) cited in Yu et al. (2007) to be those who influence, or who are influenced or affected by, the project, but are not regularly engaged in transactions with it and may not be essential for its survival. The client is the prime mover or funding organization that is directly responsible for the project development. Yu et al. (2007) noted that there are many different types of clients: Large Owner/Occupier, Public Sector, Developer, Refurbishing Retailers and Small Owner/Occupier who have different requirements and ways of going about projects.

The briefing process has been found to be the responsibility of many role players including the end-user (De Jager et al., 2009). There are cases such as in the procurement of public sector infrastructure that the client may not necessarily be the end-user. Elf and Malmqvist (2009) opined that information about the goal of the patient care and significant care processes (activities) and needed spatial factors should take a considerable part of the brief in health care because the significant end-user of the building is the patient. Lindahl and Ryd (2007) also stressed the increasing need for better briefing with focus on the end-user.

Briefing consultants include external consultants such as architects, in-house project and facilities managers, health care professionals, and health planners (Elf & Malmqvist, 2009; De Jager et al., 2009; Shen & Chung, 2006; and MacPherson et al., 1992). The health planning concept focus around the identification of a suitably experienced consultant, other than the architect to function as the briefing consultant – referred to in the health infrastructure industry as health planners. These health planners are the link between the design team and the client and are responsible for translating client requirements into design criteria. Barret et al. (1999) suggested that experience is a major driving force behind brief taking because briefing consultants/brief takers find a particular method of eliciting the client brief that suits them and tend to stick with it. According to Shen and Chung (2006), in the Hong Kong public sector, experienced brief takers mainly do the briefing.

4. Shortcomings in current Briefing Practices

A review of available literature suggests that the art of capturing and translating client requirements into functional spaces has by no means been perfected by the industry and these problems directly translate into shortcomings experienced with current briefing practices (Yu et al., 2007; Yu et al., 2005b; Kelly & Duerk, 2002; Bowen et al., 1999; and Barret et al., 1999). The following are the shortcomings in briefing practices identified by Shen & Chung (2006), Yu et al. (2005b), Kamara et al. (2001) and MacPherson et al., (1992):

- Format or lack of format and limitations of briefing frameworks;
- Lack of experience on the part of the client and comprehensive representation of all client bodies;
- Client requirement identification and processing; and
- Time allowed for briefing.

4.1 Format or lack of format and limitations of briefing frameworks

These limitations have been described as being two-fold, manifesting in shortcomings related to the format in which the brief is presented and also the brief elicitation process. In a number of studies it was evident that a documented brief was not always fully developed and that though briefing guides exist, very few brief takers make use of any real briefing guides to improve the process (Shen and Chung, 2006). It was also determined that huge reliance was placed on verbal briefing sessions and communication such as faxes and minutes of meetings to fulfill the briefing function and according to Bowen et al. (1999) and Yu et al. (2005b), the fact that the medium in which the brief is most commonly presented is oral, or a combination of written and oral is a serious shortcoming in briefing practice;

4.2 Lack of experience on the part of the client and comprehensive representation of all client bodies

It was determined by Yu et al. (2005) that the client body was not experienced enough in the building industry to make meaningful contributions to the briefing process and that not all client groups were represented in the briefing process – the dichotomy between the client and the end user.

4.3 Client requirements, identification and processing

Client requirements (CR) refer to the objectives, needs, wishes and expectation of the client, satisfying the business need of the client (Kamara et al., 2001). It emerged from previous studies that the process of eliciting and management of client requirements is not always embarked upon with due diligence and that the identification and prioritization of client requirements are often neglected. In the South African design context, Bowen et al. (1999) found out that consulting engineers are of the view that briefing team members are generally under qualified for their roles and therefore give inadequate guidance and advise to the client during the briefing process.

4.4 Time allowed for briefing

It emerged from a study by Chung and Shen (2006) that the current practice of many clients is to shorten the time required for briefing in a bid for an early start on site. Various scholars (MacPherson et al., 1992; Bowen et al., 1999; Yu et al., 2005a; Shen and Chung, 2006) consider this issue of lack of time allocated to the briefing process as a major contributing factor for poorly defined client requirements and ultimately leading to designs and buildings not meeting client/end-user need. The reasons for clients assigning so little time to the briefing process could largely be attributed to the fact that by the time most projects get to the concept briefing stage, the client is usually anxious to proceed with the project as quickly as possible, resulting in the briefing process being short circuited (MacPherson et al., 1992).

5. Quality of Brief Documents

Bowen et al. (1999) and De Jager et al. (2009) discerned that clients are not sure what they require in a project and find it difficult to describe their objectives. Nkado and Mbachu (2002) support this notion and opined that significant variance can occur between a client’s stated or perceived need and the actual need of the client. Capturing the client requirements appropriately is the root of good briefing. De Jager et al. (2009) and Yu et al. (2005b) noted that good briefs should incorporate presentation and visualization techniques and information in terms of the functional requirements of the client, that will enable the clients understanding of and participation in the development of the project, and enabling the client to play a more meaningful role in the development of the project brief.

The quality of briefs can be measured in terms of structure, context and facility that are being designed for. Elf and Malmqvist (2009) from examination of briefs for facilities in Sweden, established that many architects did not find briefing documents as useful as they should be because, the briefs are often too long and contain overly detailed specifications, which are not always clear, consistent or complete. Architects were noted to want a more structured brief with a detailed description of the context, and culture of the place they were to design. Elf and Malmqvist (2009) opined that an approach to reviewing the quality of the briefs is to study the agreement of the content in the briefs, with the design groups' actual requirements and at the same time examine critically the basis for the design decisions that have been made.

6. Indicators of Client/End-User Satisfaction

Clients according to Othman et al. (2004) are the core of construction and their satisfaction of utmost importance. Latham (1994), Bowen et al. (1999) and Othman et al. (2005) determined that client in construction do not always get what they asked for and that often design teams end up providing inappropriate buildings that don't meet the client's needs. According to Yu et al. (2007), key performance indicators including time, cost and quality as well as satisfaction, are the means by which an organization can measure the progress being made to ensure that the critical success factors are being achieved. Kotler (1997) cited in Mbachu and Nkado (2006), defines satisfaction as a person's feeling of pleasure or disappointment resulting from comparing a product's perceived performance or outcome in relation to his or her expectations'.

7. Theoretical and Analytical Framework

The theoretical framework, which is illustrated in Figure 1, is based on literature by Bowen et al. (1999), suggesting that the failure of building projects to translate into client satisfaction could be linked to inadequacies in the briefing process; and De Jager et al. (2009) that there is a common underlying premise (usually undefended) that draws a substantive link between the quality of the briefing process and the quality of the resulting building in addition to the fact that when established pockets of experienced health facility planning professionals are used, there is according to De Jager et al. (2009), far greater consistency in briefing processes and resulting infrastructure. The framework is also based on a broad consensus in the industry that current briefing practices are inadequate and fall short of delivering the intended output (Barret et al., 1999; Kamara et al. 2001; and Shen and Chung, 2006).

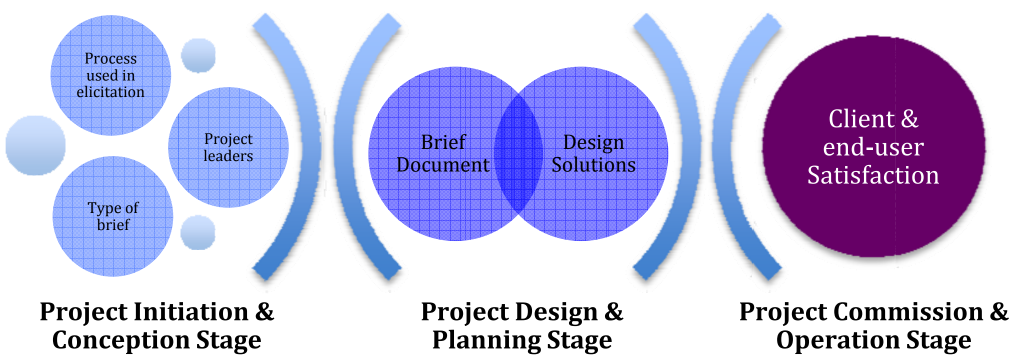

Figure 1: Theoretical Framework

Figure 1 shows that the briefing practice, including the type of project leaders/consultant, type of brief and the process used in eliciting client requirements has an effect on the quality of brief document produced and that the quality of the brief documents produced has an effect on the quality of the design solutions adopted, which affects the quality of constructed health care facility and client/end-user satisfaction. In the assessment of the quality of care, Donabedian (1988) inferred that there are causal linkages between the healthcare facility provided in terms of the structural attributes of the settings in which care occurs, the process of care, and the outcomes of care. Implying that the design solutions proffered, which is actualized in form of the completed health care facilities, contributes to a health care facility environment that is conducive for healing. It emerged from an explorative case study on the interaction between parties during the production phase by Ryd (2005) that the ways in which requirements are formulated and used for communication between the client and the contractor are very important factors in the success of a project.

There is however, a lack of empirical evidence to support the assumption that the briefing process influences the final design (Barrett and Stanley, 1999), whether the brief is a reflection of the briefing process, and whether the use of briefing or a systematic brief make a significant contribution to the high quality of design solutions (Elf and Malmqvist, 2009). Studies are therefore needed that employ different approaches that will validate or reject the assumption that the briefs are an accurate reflection of the briefing process, that the briefing process in any sense has an effect on the final results and whether the intentions of the brief can be compared with post-occupancy evaluations i.e. assessment of the results (Ryd, 2005).

8. Content and Interpretation of the Questionnaire

In order to validate the assumptions shown in Figure 1, the future study will make use of historical data on completed health care facilities in South Africa, obtained from four main participants in the briefing process including: architects/engineers (design consultants), health planners (briefing consultants), client representatives and end-users. Only completed projects will afford the researchers the opportunity to assess the end-users opinion regarding the functionality of hospital facilities. Information solicited will be through the use of three questionnaires for each completed health care facility. The first questionnaire will be directed to the briefing consultants on the project to determine the briefing practice used in the preparation of the brief documents, the type of consultant the type of brief and the process used in eliciting the client's requirements.

The respondents will be asked to indicate the designation of the briefing consultant used in public health care facilities, the prevalent briefing practice used in public hospital project procurement and if the brief developed is frozen, live or current? A live or current brief is when a dynamic approach is used in the briefing process by allowing the brief to evolve over two or three phases (De Jager, et. al., 2009; Yu et al., 2007; Shen and Chung, 2006; and Ryd, 2004), as opposed to the frozen approach when the brief does not develop past the inception/conceptual phase.

The second questionnaire will be directed at the design consultants who are the internal customers of the brief consultants in order to find out their perception of the quality of the brief document in terms of the structure, context and culture of the facility they designed. They will be required to rate these dimensions of quality on a Likert scale as highly, barely or not representative of the structure, context, and culture of the facility they designed. The respondents will be asked to determine if the brief developed is representative of the client's need and to rate the level of representation as low, average or high.

The third questionnaire is intended for the client/end-user (Department of Health and doctors, nurses and patients who make use of the health care facility), to determine if the completed health care facility matches the client requirements set out at the briefing stage and to evaluate if the end-users are satisfied with the constructed health care facility. The following specific questions will be asked:

- Is the health care facility environment conducive for healing? The patient's feeling of well-being in the health care facility will be measured on a scale ranging from pleasurable to disappointment.
- Does the constructed health care facility meet the needs specified by the client in the initiation stage? The level of achievement of the clients' need by the health care facility will be graded on the percentage of the needs achieved and level of expectation met. That is, greater than 70%; 40%-60%; and less than 40% will be rated as high, medium and low achievement respectively.

Elf and Malmqvist (2009) noted however that the possibility of using the briefs as an important follow-up document in order to assess whether the spatial design has reached the predefined goals depends on how well the goals and expected effects of the design are explicitly operationalized in the briefs. Table 1 presents the proposed variables that will be used in the study questionnaire and their designations.

Table 1: Proposed Variables and Designation

Variable	*Value*	*Levels*
Designation	1	Architect/Engineer
	2	Health Planner
	3	Client Rep
	4	End-user
Years of Experience	1	Less than 5
	2	B/w 5-10
	3	B/w 10-15
	4	B/w 15-20
	5	More than 20
Type of Brief	1	Frozen
	2	Live and current
Briefing Practice - % indication for all the options provided	1	Strategic analysis
	2	Client analysis
	3	Facilities analysis

	4 5 6 7 8	Statement of needs Confirmation of needs Functional brief Concept design Scheme design
Quality of the brief developed	1 2 3	Low Average High
Level of Satisfaction with the constructed health facility	1 2 3	Dissatisfied Satisfied Highly satisfied

9. Conclusion

Drawing on a literature review, the paper proposes a theoretical and analytical framework by which the briefing practice and process used in identifying client requirements for health care facilities can be related to the quality of brief documents and the client/end user satisfaction in the constructed health care facility, using historical data and case studies. Substantiated knowledge that there is a significant relationship between briefing practices and quality of brief documents and client/end-user satisfaction in constructed health care facilities, will help the Department of Health in the choice of a brief practice which will comprehensively capture their requirements, give clear directives/information to the design consultants and will result in higher levels of end-user/patient satisfaction in the constructed health care facility.

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Driving sustainable innovation through procurement of complex products and systems in construction

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Abstract

This paper will explore how procurement of complex products and systems by the demand side may drive sustainable innovation in the construction business system. In recent years, (public) procurement of complex products and systems has increasingly been advocated as a complementary yet powerful strategy to drive innovation for sustainable construction. Such a demand-oriented innovation strategy has been pushed not only by national agencies, but also by international bodies like the United Nations and notably by the European Commission through its Lead Market Initiative. Based on an on-going case study of procuring a complex construction project, this paper emphasize the complex and emergent character of the demand side in construction and argues for a stronger analytical sensitivity towards the various actors and activities on the demand side of construction. Further, this paper makes a preliminary investigation of the various types of constituents of construction. In particular, this paper argues for a distinction between building owners and users in an analytical model of innovation in complex products and systems like construction. Finally, this paper argues that procurement of complex products and systems may reshape the linkages between the various constituents of construction through policy processes, business processes, and learning processes, and the paper hypothesises on the dominant character of these linkages.

Keywords: Innovation, Construction business system, Procurement, Complex products and systems (CoPS), Sustainability

1. Introduction

Public policies and public procurement have played an important role regarding innovation in the construction industry (see e.g. Manseau & Seaden (eds.), 2001 and Edler & Georghiou, 2007). In recent years, (public) procurement of complex products and systems has increasingly been advocated as a complementary yet powerful strategy to drive innovation for sustainable construction (see e.g. SCI-network, 2011).

Clients – and in particular public clients – play a crucial role in these demand-oriented innovation strategies, and clients have been called upon to become change agents of the construction industry. Various national building policies, the establishment by CIB of the International Construction Clients Forum (ICCF) and increased research interest (see e.g. Brown et al. 2005 & 2006) have tried to mobilise clients to encourage innovation.

Such a demand-oriented innovation strategy has been pushed not only by national agencies and research institutions, but also by international bodies like the United Nations and notably by the European Commission through its Lead Market Initiative. While more ordinary projects may maintain and sustain existing practices and principles, procurement of complex products and systems potentially opens up the black box of construction and provide an avenue for studying the fundamentals guiding the practices and principles of construction actors and activities. Thus, this paper is based on a case study of procuring a complex construction project by an international construction client.

2. Research methodology

2.1 Complex products and systems

Hobday (1998, 2000a) has introduced the term complex products and systems (CoPS) and emphasizes CoPS as the chief unit of analysis for innovation, management and competition analysis rather than the single firm. Hobday (1998: 689) argues that the dynamics of innovation in CoPS are likely to differ from mass produced commodity goods due to its distinctive characteristics. CoPS are characterised by being highly customised, engineering-intensive goods, which often require several producers to work together simultaneously. Hobday (2000a: 691-693) identifies a set of indicators of critical factors, which defines the complexity of a CoPS. These include among others the quantity of tailored components and sub-systems, the hierarchical manner in which they are integrated together, the degree of technological novelty of the CoPS in question, and the variety of knowledge bases included in the CoPS. Further, user involvement in innovation tends to be high, and suppliers, regulators and professional bodies tend to work together with users ex-ante to negotiate new product designs, methods of production and post-delivery innovations. Markets are often bureaucratically administered, and contestability is low in contrast to commodity goods, which are characterised by arms-length market transactions. Examples of CoPS include a range of buildings and constructions, aircrafts, ships, telecommunications networks and a range of military equipment like missile systems and battle tanks.

In another paper, Hobday (2000b) examines if a project-based organisation is the most appropriate delivery mechanism for complex products and systems compared to a more functional matrix organisation. Based on a case study of a large manufacturer of a wide range of advanced, high-cost scientific, industrial, and medical equipment, the paper illustrates the wide variety of organisational choices involved in producing CoPS and points out that the nature, composition, and scale of the CoPS in question is important for the appropriate choice of organisational form.

Hobday (2000b) identifies some of the strengths and weaknesses of the two organisational forms for CoPS production. The project-based organisation is capable of:

- Creating and recreating new organisational structure around each CoPS and customer.

- Coping with emerging properties in production and respond flexibly to changing client needs.

- Integrating different types of knowledge and skills and coping with the project risks and uncertainties common in CoPS projects.

The matrix organisation has its strengths where the project as organisational form has its weaknesses: in performing routine tasks, achieving economies of scale, coordinating cross-project resources, facilitating company-wide technical development, and promoting organisation-wide learning. Further, project interests and incentives can work against the wider interests of corporate strategy and business coordination.

In line with the work on CoPS, Gann & Salter (2000) provides an analytical framework for understanding the construction industry as embedded in a context of both policy-making (regulatory and institutional framework) and knowledge production (technical support infrastructure). The model recognises not only the actors, but also the activities taking place. Further, the model acknowledges not only the construction industry in a traditional sense – namely contractors and consultants – but it also includes the clients of construction as well as the manufacturing industry delivering products for construction. Based on this resource-based perspective, Gann & Salter (2000) frame the links between different actors and activities as knowledge flows (see Figure 1).

As pointed out by Gann & Salter (2000), a major challenge for project-based firms is to link the project-based processes with the business processes of the firm. The project-based nature of construction implies that the interdependencies are primarily linked to the rather fluently, changing and ad-hoc patterns of cooperation with a rather great number of external firms. These links are important due to the relative high degree of autonomy of the individual project, while the individual projects to a large extent determine the overall performance of a firm.

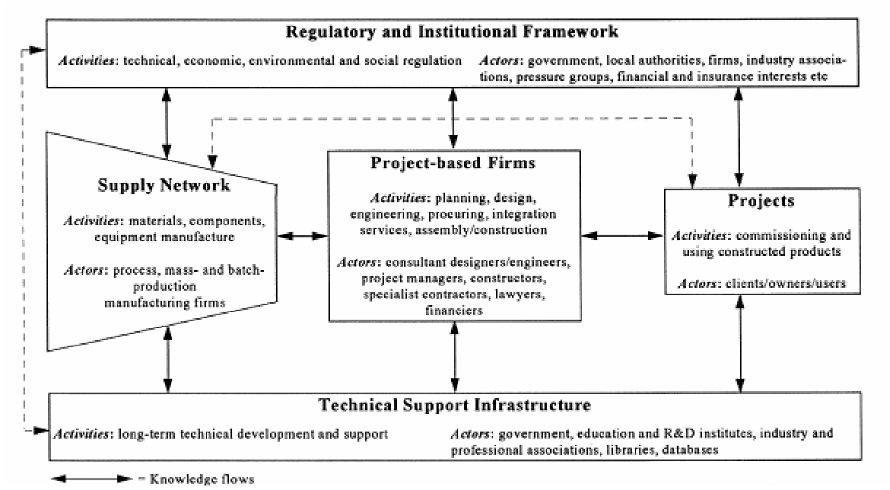

Figure 1: Knowledge, information flows and actors in project based processes. Source: (Gann & Salter, 2000: 960).

What is less clear is the character of these linkages. Haugbølle & Forman (2011) have identified a number of theoretical perspectives on these linkages in construction as: 1) knowledge flows (e.g. Gann & Salter, 2000), 2) functions and regulation (e.g. Carassus (ed.), 2004), 3) governance processes (e.g. Winch, 2000 & 2002), 4) a loosely coupled system (e.g. Orton & Weick, 1990; Dubois & Gadde, 2002), and 5) strong/weak ties (e.g. Granovetter, 1973; Pryke, 2004 and Chinowsky et al., 2008). Haugbølle & Forman (2011) propose an alternative perspective on these linkages as being constitutive rather than being fixed and taken-for-granted, which in turn explores and challenges the very ontologies at play (explanans/explanandum) when it comes to analytical units (project/firm), relations (couplings) and effects (performance/innovation).

2.2 Case study design

This study is based on a case study design (Yin, 2009). It should be noted that this article presents preliminary observations and conclusions from an on-going research project. The case is considered to be an exemplary case due to its characteristics:

- The case represents state-of-the-art when it comes to diminishing the need for use of car transportation to get to the office and its energy performance requirements both in relation to building regulation and environmental certification.

- The building represents a complex product and systems due to among others its size, geometry, location and extensive safety protocols.

- The project represents complexity not only in relation to the product but also the process, in particular when it comes to the organisational setup on the client side.

The methods for collecting and analysing data include analysis of documentary material, a visit to building site, public presentations of the project and seven designated student reports following a course on construction management.

3. Case: UN City in Copenhagen

3.1 Background – city development and Nordhavnen

The capitol area of Copenhagen is growing quite rapidly. The number of inhabitants is expected to increase by 100,000 people or 18 % by 2025. At the same time the business structure is changing rapidly. Heavy industry is disappearing from for example the harbour of Copenhagen. These changes free up new areas for urban development. One of the most prominent areas is Nordhavnen, the Northern Harbour of Copenhagen (BY & HAVN, 2009).

In December 2005, the Danish government and the City of Copenhagen agreed on the principles that would govern urban development in Nordhavnen. This agreement was turned into an act of parliament that was adopted on 22 May 2007. In May 2008, an open international ideas competition on the sustainable city of the future was launched. The competition attracted some 180 proposals, and in March 2009 the results were announced. The winning proposal titled “Nordholmene – Urban Delta” was developed by a team of COBE, SLETH MODERNISM, Polyform and Rambøll. During the summer of 2009, the winning proposal was reviewed, and its development strategies were further detailed and specified. The six themes of the winning proposal are 1) Islets and canals, 2) Identity and history, 3) Five-minute city, 4) Blue and green city, 5) CO_2 friendly city, and 6) Intelligent grid. During 2010-11, the Municipality of Copenhagen developed a Municipal Plan supplement and local plan for Nordhavnen (BY & HAVN, 2009).

Nordhavnen is expected to be developed over the next 40 years to house 40,000 inhabitants and 40,000 employees. The development of Nordhavnen is divided into three stages. In the first stage, the inner Nordhavn (the so-called Århusgade Quarter) comprise some 350,000 m^2 of new gross floor area and the preservation of existing buildings with a gross floor area of 70,000 m^2. The Municipality of Copenhagen has recently adopted the urban plan for this stage to be initiated. In the second stage scheduled to start in 2018, additional 200,000 m^2 may be developed. In a third stage not yet detailed, the entire Nordhavnen may eventually be developed to include buildings with a gross floor area of 3-4 million m^2 (BY & HAVN, 2009).

3.2 The UN City

The UN City is the first of a number of new buildings to be constructed in the inner part of Nordhavnen. The intention of the UN City is to have all of the representations of the United Nations in Denmark gathered in one location. Today, United Nations have six agencies in Denmark located in different locations with some 1,100-1,200 employees. The six agencies include the Nordic Office of

UNDP (UN Development Programme), the European headquarters of WHO (World Health Organization), the headquarters of the Supply Division of UNICEF (UN Children's Fund), one of the Liaison Offices of WFP (World Food Programme), one of the Liaison Offices of UNFPA (UN Population Fund) and the headquarters of UNOPS (UN Office for Project Service).

Although the intention was to gather all UN activities in one place the UN City now actually consists of two campuses at the inner part of the Northern Harbour of Copenhagen (Nordhavnen). Campus 1 encompasses the domicile of UN and is situated on the Marble Pier (Marmormolen) in the port of Copenhagen, immediately adjacent to the existing UNICEF warehouse. Campus 2 include a fully automated high bay warehouse for UNICEF with a capacity of close to 40,000 cubic meters, which is being built in the Free Port at the outer part of the Northern Harbour of Copenhagen and ready for moving in at the beginning of 2012. The warehouse will handle goods for development and emergency projects around the world.

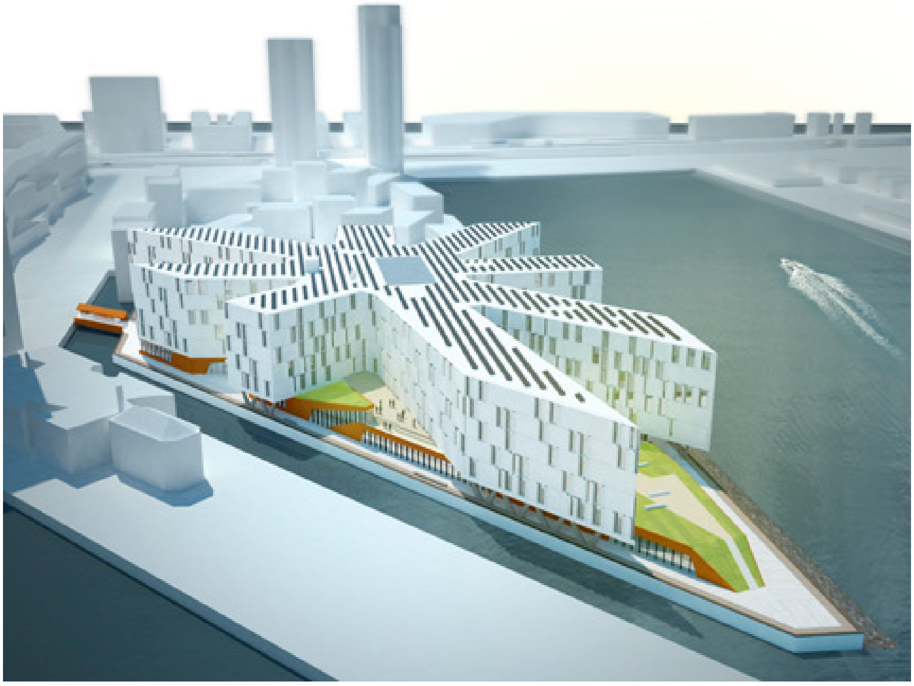

Figure 2: The star-shaped UN City. Architects: 3XN A/S.

The new domicile of UN at Campus 1 will be constructed in two phases. The first phase covers the construction of some 28,000 m^2 gross floor area and some 5,000 m^2 basement in one storey for technical installations and storage. This phase is expected to be finished in the beginning of 2013. The building will be constructed as a star-formed building with 8 "arms", of which phase 1 consists of the central and Eastern part of the star making up the first five "arms" (E. Pihl & Søn A/S, 2012).

In the beginning of 2014, the second phase will complete the star by adding the last three "fingers", when the existing UNICEF warehouse has been demolished. This will increase the gross floor area with 17,000 m^2 to a total of 45,000 m^2 and add some 3,000 m^2 extra to the basement. The building will be constructed as low-energy class 1 building according to the Danish Building Regulation (energy consumption below 50 kWh/m^2/year). Further, the building has been designed to be certified according to the American certification scheme LEED (Leadership in Energy and Environmental Design) with the goal of achieving a minimum score of LEED Gold and reaching at least 73 LEED points according to Version 3 of the LEED scheme. The building will be using recycled rainwater for toilet flush, cooling will take place with sea water, all lighting will be automatically controlled, and photo-voltaic cells will be installed. Due to strict security reasons, the building is being constructed at an isolated island linked to mainland through one bridge accessible only by foot and with small vehicles. In addition, the developer FN-BYEN P/S became a Green Building Partner as one of the first Danish organisations. The main requirement of the European Union's Green Building scheme is to reduce the energy consumption with 25 % compared to national regulation (European Commission – Joint Research Centre – Institute for Energy and Transport, 2006).

3.3 Procuring a new headquarters

The development of Nordhavnen is carried out by the developer CPH City Port and Development I/S in collaboration with the Municipality of Copenhagen. CPH City Port and Development was established in October 2007 and is owned 55 % by the Municipality of Copenhagen and 45 % by the Danish government (ownership exercised through the Ministry of Transport). CPH City Port and Development is responsible for the development of the properties owned in Ørestad and the harbour of Copenhagen along with the operation of the port activities through the subsidiary Copenhagen Malmö Port (CMP). The company is required to carry out its activities on ordinary commercial grounds, for example through the sale of building rights.

The local plan of Marmormolen was approved by the Municipality of Copenhagen on 10 December 2009. The local plan includes 23,000 m^2 office buildings, 28,000 m^2 housing, a hotel of 25,000 m^2, the 45,000 m^2 for the UN City and 58,000 m^2 for the so-called LM Project. The LM Project includes two office towers at Marmormolen and the tip of Langelinie, and connected with a bicycle and footbridge in a height of 65 m (Københavns Kommune, 2010).

The development of Marmormolen (the Marble Pier) was initially handled by the consortium Byggemodningsselskabet Marmormolen P/S owned by CPH City Port and Development (50 % ownership) and the private investor N&S P/S (50 %), which in turn was owned by Nordkranen A/S and SNS Property Finance. During 2011, the ownership rates were changed to 90 % for CPH City Port and Development and 10 % for N&S P/S. In December 2011, a new consortium called Harbour P/S owned by CPH City Port and Development (8.5 % ownership) and the two pension funds ATP (45.75 % ownership) and PensionDanmark (45.75 % ownership) bought for 2.1 billion DKK the UN City along with the building rights for the so-called LM Project. CPH City Port and Development put up the concluded UN City and part of the LM Project as investment and hold a minor share of ownership. The agreement will be effective by the middle of 2013.

The UN City was developed by the company FN-Byen P/S with the associated limited partnership company. The company was owned by CPH City Port and Development (99.2 % ownership) and

Nordkranen A/S (0.8 % ownership). The purpose of the company is to prepare the area for construction, to construct and let properties at Marmormolen.

While the ownership of the UN City is with the consortium, CPH City Port and Development is the building client and the letting office of the property. The Ministry of Foreign Affairs will be the lease-holder on a long-term lease contract, while the UN representations are the actual users of the UN City. On behalf of the UN representations, the Ministry of Foreign Affairs has hired Alectia and PLH Arkitekter as consults for the user organisations. As is customary for UN representations, the nation hosting the UN representation will make properties available to the UN representations and pay the lease. As The Ministry of Foreign Affairs does not in itself have the necessary skills and organisation to manage building projects, the ministry is obliged by law to have the Danish Palace and Property Agency of the Ministry of Finance as construction and facility manager.

The new UN City has been designed by one of the leading Danish architectural firms 3XN A/S, who were also involved in creating the master plan for the Marble Pier together with architect Kim Utzon (for the hotel), SCHØNHERR LANDSKAB (the landscape) and Steven Holl Architects (the LM Project), which formed the backdrop for the local plan. The consulting engineers are Leif Hansen Rådgivende Ingeniører A/S, who merged with Orbicon during the project.

The land development was undertaken by the contractor Aarsleff A/S as a turnkey contract and with Tscherning as sub-contractor. The detailed design and construction work is also undertaken as design-build contract. After a pre-qualification round, six contractors were selected for participation in the limited tender in the period 15 March 2010 – 17 May 2010, which was based on economically most advantageous tender and followed the European regulation on public tendering (Public Sector Procurement Directive, Council Directive 2004/18/EC). The contractor E. Pihl & Søn A/S won the tender. Part of the tendering requirement was the obligation of the contractor to take over the consultancy team of 3XN A/S and Orbicon/Leif Hansen Rådgivende Ingeniører A/S. Later the contractor Pihl & Søn A/S also won the tender for the phase 2 extension of the UN City.

4. Discussion

As examined in the research methodology, Gann & Salter (2000) provides a framework that understands the project with its actors and activities as a central constituent in the development of complex products and systems within construction. Below, we will critically discuss this central constituent of the model by Gann & Salter (2000) and propose a somewhat different perspective.

First, this case study has illustrated the complex and emergent character of the demand side in construction. As has been emphasised by the Swedish Engineering Academy (IVA, 1997) the client side of construction can be understood as a nodal point having relations to four groups of actors: the construction industry, the regulatory system, the users and the building owner. The case study has illustrated how the demand side of construction may be very complex with multiple user organisations (in this case six UN organisations), extensive role separation (as owner of building rights, developer, construction client, building owner, financier, user, tenant, leaseholder and letting office) along with overlapping roles between the regulatory system and the business (the double role of the municipality as both authority and part owner of the developing company), and repeatedly changes in the ownership structure over time. Thus, we would like to challenge the rather monolithic perspective on the demand side of construction as expressed in Gann & Salter (2000).

Second, we have preliminarily investigated the type of links between the various constituents of construction. Undoubtedly, the links can be perceived as knowledge flows as argued by Gann & Salter (2000), but we would like to hold that there is more than knowledge flows at play. In fact, we may perceive construction as a technological system and ask through which technologies the interactions between the various constituents of construction take place. Technology may be perceived as the sum of artefacts, processes and knowledge. As the case study illustrates, the relations between the various actors are kept in place via a diversity of technologies. These include financial instruments like capital investments, organisational arrangements like competitions, artefacts like drawings and construction equipment etc., contractual arrangements like building rights and many others.

Previous policy analyses of the Danish construction industry as a resource area (Erhvervsfremme Styrelsen, 1993 and 2000) have pointed towards an understanding of the interactions as taking place through three distinctively different yet interrelated markets:

- A product market between the supply network and project-based firms.

- A construction market between the project-based firms and the building owners.

- A property market between building owners and users.

Thus, we would like to propose a somewhat different perspective on the constituents of construction as illustrated below in Figure 3. More specifically, we would like to introduce a clearer distinction between building owners on one hand and users on the other hand. In most cases, the building owner and users will be interacting through a property market either through sales or leases.

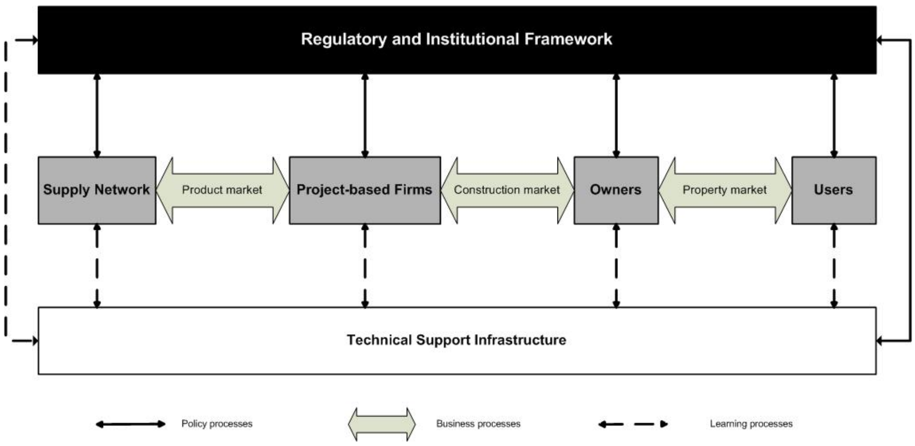

Figure 3: An alternative perspective on the construction system. Source: The author.

Third, we would also like to hypothesise on the dominant character of the links between the various constituents. Thus, we would like to suggest that the interactions between actors take place through policy processes, business processes and learning processes. This is not to say that all processes are at play with the same weight in all situations or between all actors. Business processes seems to be particular important when it comes to the interactions between the supply network, project-based firms, building owners and users as most of the products and services being exchanged happens in various kinds of markets. The interaction between the regulatory and institutional framework on one hand and business and technical support infrastructure on the other hand may be more dominated by policy processes of policy-making and implementation. The interaction between the technical support infrastructure on one hand and the business and regulatory framework on the other hand may be dominated by learning processes related to the development and transfer of knowledge.

5. Conclusion

Based on an on-going case study, this paper has explored how procurement of complex products and systems by the demand side may drive sustainable innovation in the construction business system.

First, this case study has illuminated the complex and emergent character of the demand side in construction and argued for a stronger analytical sensitivity towards the various actors and activities on the demand side of construction.

Second, this paper has made a preliminary investigation of the various types of constituents of construction. In particular, this paper has argued for a distinction between building owners and users in an analytical model of innovation in complex products and systems like construction.

Third, this paper has argued that procurement of complex products and systems may reshape the linkages between the various constituents of construction. The paper suggests that these interactions take place through policy processes, business processes and learning processes, and the paper hypothesises on the dominant character of these linkages.

6. Acknowledgements

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Why Don’t Public Clients Aggregate their Purchase of Construction Materials Over all Projects to Save Money?

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Abstract

The public sector is a major client of the construction industry for new build, refurbishment and maintenance. In the UK, the quantity of public sector work is much less than it was 40 years ago, but it still directly amounts to ~40% of all construction. Construction materials amount to about 30% of total development cost including land. In the UK, the traditional way that Local Authorities (LAs) purchase materials for this work is through their contractors for each project. With such a significant purchase value, it has been suggested that LAs should aggregate their purchasing across all their projects so as to achieve reduced costs and better availability of materials for their projects. This paper analyses why this ‘good idea’ is difficult to achieve in practice. The work is based on a small number of interviews with LA officers, construction contractors working for LAs, and specialist procurement staff. It was found that most participants do not have an understanding of how materials procurement interacts with the construction process, and that there is little actual information of what quantities of each type of material are used. The decision process is analysed using the theoretical work of Boyd and Chinyio (2006) to determine the barriers to adoption of this ‘good idea’ and this is related to the stakeholder needs of the participants. It is argued that what is an apparently simple change in one domain has complex consequences in others which would continually prevent success. The ability of public sector to be explicit about what it wants to achieve is limited by regulation and a need for absolutely transparent accountability and this inability to articulate and discuss the issues prevents a resolution being found. It is suggested that any such change would only be possible if other comprehensive changes take place at multiple domains in the procurement, design and construction of projects

Keywords: clients, procurement, strategy, change, construction process

1. Introduction

The public sector is a complex client of the construction industry as it experiences diverse pressures on it from external non involved groups. Politicians use the construction industry to stimulate economic development but criticises it; voicing an expectation to deliver more output at less cost and to improve their efficiency (Gershon 2004). The advent of the financial crisis has given this tension more significance but improving public sector construction in the UK has been a challenge for decades (Murray et al, 2003). The enormous effort that has been put into this on-going problem variously comes up with solutions to do with processes, contracts or relationships. The strategies for achieving cost reduction can be divided between production solutions and procurement solutions. In the former, the ideas are to reduce material and labour costs and include LEAN which focuses on waste removal (Koskela 2000). In the latter the idea is to reduce transaction costs from bureaucracy, fragmentation and conflict (Winch 2002) and the subject of many changes in the process of construction (NAO 2006). In the latter, the inefficiencies of competitive tendering have been overcome by a move to partnering during projects and a longer term relationship through framework agreements. In the UK, this has all taken place under the procedural eye of the European Union where competition and supply have to be maintained across Europe.

The subject of construction materials is an obvious area of cost reduction but this has mainly focussed on using less and using lower cost components such as through standardisation. It is a rule of thumb that material costs of construction amount to approximately 33% of the cost of a building with a further third being labour and the final third being land. There are movements in this relationship as at the moment material costs are rising and labour and land costs are falling (BCIS 2011). In addition the proportion is different in different building types with materials commanding a greater proportion in highly serviced buildings such as hospitals. In the UK, the Bill of Quantity was devised to try to systematically get the use of materials and so building cost under control (Ashworth 2005). Such an approach is also used to feedback to designers about what the costs of their designs are. Value engineering (Green and Popper, 1990) is a more up to date attempt to establish a functional value of undertaking design and construction in a particular way and to encourage more functional and cost effective design solutions.

The ‘good idea’, that it is possible to reduce costs of materials through aggregating purchasing over all project, is not new. The rise of supply chain management, as championed by the retail industry with its need to deal with many suppliers and for organising logistics (Cram, 2010) is driving a belief that it is possible to get similar benefits in construction. Thus, ideas of centralised purchasing which works with a reduced number of suppliers and longer term relationship and partnering, are in favour. In construction, such arrangements have always been looked at suspiciously for corruption and non-competitive practices particularly under EU legislation. However, the use of long term framework agreements has been championed (Constructing Excellence 2005) and there has been a notable success in Birmingham (OGC, 2005). Given these achievements and those of the retail industry, it was obvious to consider trying to save money from the supply of materials and this paper considers this apparently simple, but actually deep, change in approach for Local Authority construction. Sometimes referred to as collaborative or aggregated procurement, this would involve purchasing materials across projects in order to gain cost savings from bulk purchase and better alignment of products to need. Further, this aggregation should take place across local authorities in a region through the Local Enterprise Partnership (LEP).

The idea of bulk purchase and collaborative procurement was identified in the 1930s e.g. the UK Ministry of Health produced a report on the Standardisation and Simplification of the Requirements of Local Authorities in which it stated ‘Purchasing in bulk is the natural corollary to simplification of requirements’ ...... ‘We urge that all appropriate local authorities should consider the setting up .... a Central Purchasing Committee’ (quoted in Bird (1936) who was taking these ideas forward). The idea of public sector collaborative procurement returned to the government agenda in the early 2000’s and many approaches were instigated (OGC, 2007). This included the UK government setting up regional RIEPs (Regional Improvement and Efficiency partnerships) which were tasked with driving changes in local authorities. Pidgeon (2009) provides an instructive summary of the benefits to local government and describes a number of initiatives. The National Audit Office undertook a review of Collaborative Procurement across the Public Sector (NAO 2010) and suggested savings of many hundreds of percent. Pidgeon (2009) has much lower figures of 2-6% on commodities but 26 to 40% on contracts such as framework agreements in construction.

Collaborative procurement may be organised on a member owned or third party basis with the former being run collectively by councils and the later using a specially set up organisation (Bakker et al, 2006). The later charges a percentage and is effectively a sub-contract supplier. Buying consortia and purchasing clubs operate on a member owned basis. As a member run enterprise, tasks and particular commodities are adopted by individual local authorities to lead on: determining agreed specifications, and negotiating best value contracts, purchasing arrangements and ordering. These are taken to a consortia board and agreed. There are a small number of examples of such activities in construction which can be regarded as precursors to the current idea; these include: buying consortia, consolidation centres and early supplier and manufacturer involvement. For example, Black Country Purchasing Consortium and the Midlands Highways Buying Alliance are voluntary member run organisations. The former is a consortium of four local authorities: Wolverhampton, Dudley, Sandwell, and Walsall. It has been in operation since the mid 1980s and includes a small number of construction materials: glass, concrete, power tools and copper tube. The consortium board agrees a lead authority for each commodity which then distils an agreed specification, a negotiated supplier contract and an agreed method of procurement. Some commodities are negotiated on a fixed price basis (e.g. protective clothing) and others using a price index (e.g. copper tube and fittings) where there is a volatility of commodity price. Although this was successful, there has been a reduced use in the last few years because of the removal of housing repair and maintenance in these authorities to ALMOs (Arms Length Management Organisations) and a perception that the discount received by the consortia was not substantive. This has seen a return to LAs doing their own thing locally. The Midlands Highways Buying Alliance was started in 2007 through the East Midlands RIEP with over £250,000 funding for organisation of nine councils. This initially concentrated on organising framework agreements for contractor procurement but has now worked on the joint procurement of surface dressing, street lighting, kerbs, salt and vehicles. Savings of about 6% have been achieved and again there is a good experience of arranging joint specifications, supplier contracts and delivery. Such practices do show it is possible to agree specifications and negotiate contracts across authorities.

Construction consolidation centres collect and distribute materials for multiple construction sites in busy inner city areas such as in Bermondsey London (Constructing Excellence 2006). Manufacturers deliver to the Centre in relative bulk to be 'called off' by trade contractors in the quantities required for use in the immediate future. The system uses a 'just in time' approach and provides a checking of quantity and condition, and an ability to deliver to the precise points on site for more effective use and reduced on site storage. Materials are 'consolidated', to avoid the delivery of multiple part-loads to make more efficient use of distribution vehicles avoiding congestion and reducing transport environmental impact. These seem to be mainly used where storage and transport are difficult such as in busy city centre locations and do not advertise cost reduction in bulk buying. Early manufacturer and supplier involvement is based on the idea that too much time is wasted on a construction site making designs work in practice; the solution being to integrate production and supply into design. (Constructing Excellence 2004). This seems to be about getting products which meet difficult needs and do so without difficulties of production, however, there is no suggestion on cost saving.

This paper considers the viability of this idea of aggregated procurement of construction materials by a group of local authorities. This study analyses this idea through the client behaviour theory of Boyd and Chinyio (2006) which is a systems based theory. The analysis looks at what can be done theoretically and what can be done in practice. The paper concludes that such simple ideas actually require complex change in the system of operations and commitment at all levels and this is very difficult to control in the differentiated public sector client where much is un-discussable.

2. A Theory of Clients

Boyd and Chinyio (2006) created a complete model of client behaviour which is valuable in the study of a complex client like a local authority. They see clients operating in a business or public service context which determines the client’s structure, processes and engagement with construction. Clients have problems even before they engage with construction; construction explicitly is seeking to change the client thus exacerbates these existing problems. Clients are driven to achieve their needs in building on two fronts; the explicit, formal engagement and the hidden, emotional engagement. These fronts operate differently and with different pressures making the means of construction volatile and uncertain with consequences seen differently by different parties. The successful end of construction is a result of managing the means so that the gap between aspirations and reality is acceptable on both fronts for the participants.

Boyd and Chinyio’s (2006) analysis of the public sector client represents its structure through domain theory (Kouzes and Mico 1970). This differentiates a political, managerial and operational domain to the enterprise. The circumstances of the public sector require it to have explicit accountability which dictates that a Local Authority tends to work by implementing rational procedures. It is the achievement of this which is defined as quality. This bureaucratic model of the public sector is changing with the advent of neo-liberalism where the public sector is required to act like the private sector (or indeed be constituted as this). . In Boyd and Chinyio’s (2006) approach it is necessary to map the environment of the client in order to identify the influences on the system, and also to map the means and ends drivers that determine the success of building. These are shown in Figs. 1 and 2. Boyd and Chinyio’s (2006) determine that the public sector operates with different end values in each domain as presented in Figure 2; political domain involves achievements ascribed to a political party, public acknowledgement of this and the devaluing of opposition approaches; managerial domain involves value for money, targets met, services delivered, and documentation complete; operational domain involves: procedures undertaken, building enhanced, and no dissatisfied clients. As has been stated, in the UK all domains share the end value of accountability which means that every action needs to be justified explicitly including the consultation on a decision, the making of the decision and its enactment. Although accountability is an internally delivered value, it is supervised by an external independent public authority in the UK, the 'district auditor', but also the ever vigilant press hoping to identify further public sector incompetence spurred on by opposition politicians. It is this context where public sector managers and technicians try to maintain their own personal end values: a sense of achievement, opportunities, quality of life, job security and no blame.

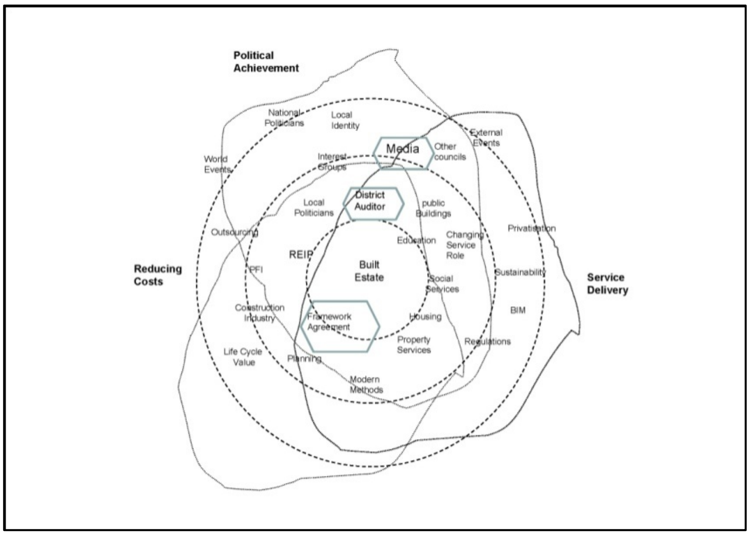

Figure 1 Map of Local Authority's Building Environment

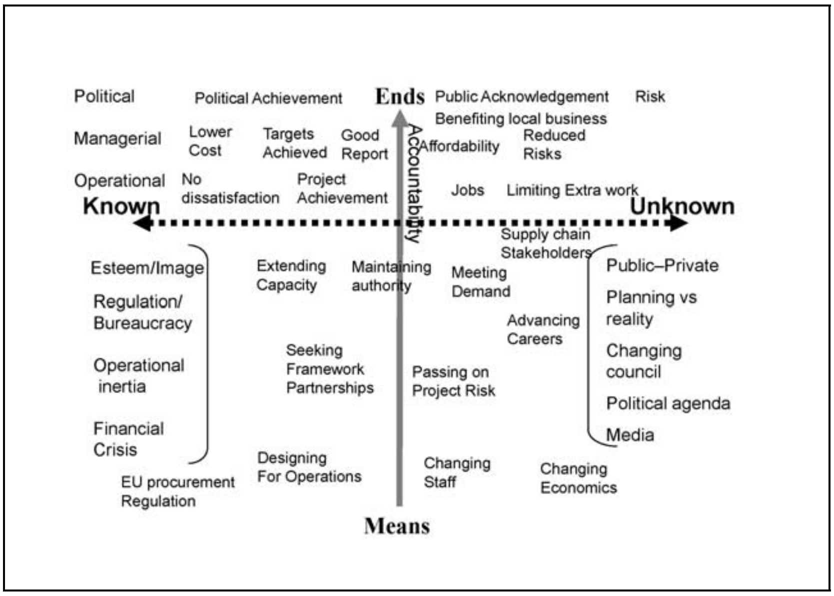

Figure 2 Means and Ends of Local Authority Service

This structure of the client’s environment and their end values determines how building is conducted, i.e. the ends determine the means of building as represented in Figure 2. The drive for accountability as an end determines that objective planning and delivery through formal procedural are essential for survival in the public sector at the same time many public sector workers believe passionately in the social economy and seek to support this against mere financial decision making. Thus, the contradictions of the public sector are many and are particularly complex because of the impossibility of discussing them openly and this issue will be key to instigating a major change. As Boyd and Chinyio (2006) emphasise ‘it is the emotional dimension that is significant during change when opportunities become available or losses are experienced’ and this paper is about multi-dimensional change as a result of the ‘good idea’.

3. A Study of a ‘Good Idea’

This research was commissioned by a local authority consortium to analyse the potential for ‘good idea’ specifically the collaborative procurement of construction materials. This project was a short scoping exercise in order to

- establish the way selected LA's in the West Midlands procure and specify construction works and in particular specify construction materials
- investigate the opportunities and barriers for bulk purchasing and specifying across selected LA in the West midlands
- determine recommendations for progressing such an initiative

The research involved a process mapping exercise and a stakeholder analysis. The latter involved in-depth interviews of construction procurement people in: different local authorities, construction contractors, and procurement agencies as well as a review of literature on the subject. A set of questions was devised to determine current budgets, current subcontracting arrangements, current problems, arrangements for specifying materials and problems particularly around team decisions, identification of opportunities for bulk purchasing, awareness of other such arrangements, the use of term contracts and an overall statement on the viability of collaborative purchasing.

The initial study determined the key issues about materials which allowed the creation of a process map. Some of these key issues of construction materials are to do with the range and diversity of these which can be specialist components such as boilers to bulk commodities such as cement. The range of materials has differing characteristics, needs for use, and purchasing requirements. The various stakeholders have differing needs and responses to the idea of collaborative procurement. Local authorities are as interested in supporting their local businesses as in saving money and they have a general concern about correctly meeting EU procurement legislation. Materials are initially specified by designers or surveyors who have a desire for quality and fitness for use. The contractor who purchases the materials is interested in delivery and buildability but is also keen on benefiting from its own aggregation. There is no overarching management of materials establishing a value and effective use. This means that suppliers and manufacturers have little information about planning their production but they would certainly benefit from a predictable flow of orders. Currently, they have great uncertainty about which components and commodities need to be developed to meet client needs better as contractors merely chose from what is available.

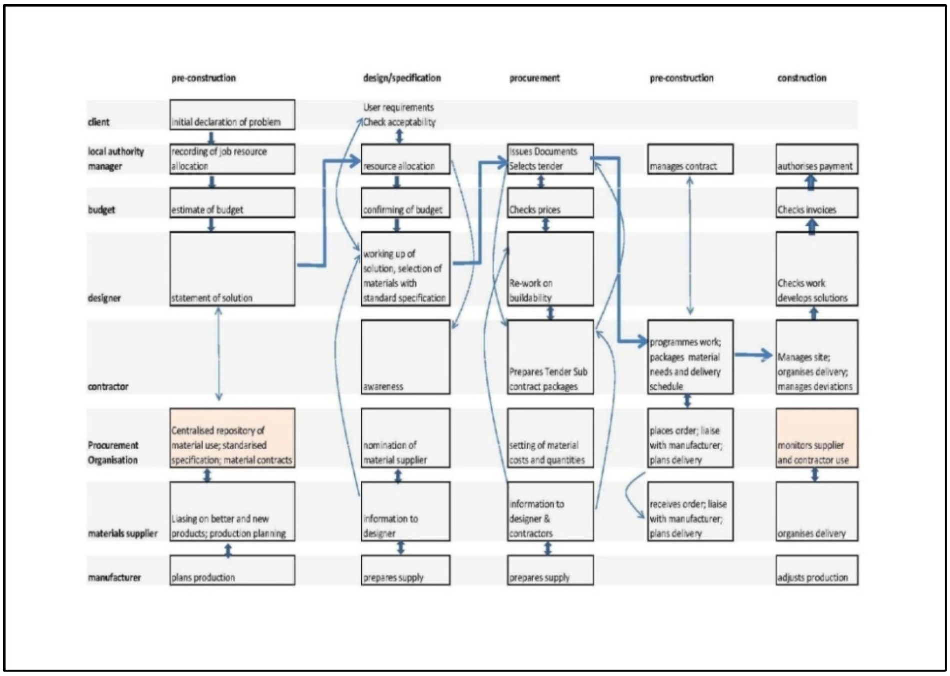

Figure 3 Process Map for Aggregated Procurement

	Objectives	Benefits of Collaborative	Barriers to Collaborative
Client	Quality of provision	Cost savings	Non Use of local firms
	Speed of response		Limited specification
	Minimum cost		
Designers/ Specifiers	Flexibility to select what is	Cost saving give more work	Loss of choice
	High quality	Less problems in specification	Unfamiliarity with products
	Renown for quality	Attention from suppliers	Worry of blame for failure
			Belief that products selected on price rather than quality
Construction	Reliable profit	Correctness of specification	No control of product
	Renown for achievement	Fluid planning	Loss of relationship with supplier
	Timely delivery	Less materials' complaints	Loss of own aggregation
			Failure of delivery
			No flexibility if errors
Sub-contractors	Reliable work	Familiarity with products	Failure of delivery
	Reliable payments	Reliable work planning	No flexibility if errors
Supply Companies	Margins	Order quantity	Lower margins
	Order quantity	Flow of orders	
	Flow of orders	Planned lead times	
Manufacturers	Margins	Reliable orders	Lower margins
	Order quantity	Planned manufacture	More demands on products
	Flow of orders	Ideas for new products	
Local authority management	Want No worries,	Clear goals	Loss of autonomy
	Does it work.	Lower costs	Complaints from designers
	Client satisfaction	Easier management	Complaints from politicians
	Easy to administer		Changes and flexibility less easy
	Acclaim from Politicians		Overall system too complex

Table 1 Stakeholder Views of Aggregated Procurement

A new process map was developed for aggregated procurement and this is shown in figure 3 which demonstrated the viability of the ‘good idea’. However, looking more deeply at the needs of stakeholders, as shown in table 1, there are different objectives, benefits and barriers for each which highlights a problem for the ‘good idea’ to be realised. Even though everyone espoused that there were opportunities to cut costs and deliver other benefits from coordinated approach to materials, there was no simple and obvious model to move to for collaborative materials procurement in construction. There was clearly insufficient information on materials needs and uses. Various stakeholders indicated that any approach required standardisation of specification and a limiting of choice by designers. Key requirements other than cost must include delivery, error management and cost indices to maintain value from centralised purchase.

This was analysed in an earlier study (Boyd 2011), through a soft systems approach of Checkland (1981) exploring systemic feasibility and cultural viability. The systemic feasibility was identified as the process map which demonstrated that change was possible. However, there are a number of significant disturbances on the systemic feasibility and cultural viability of the change in the case of aggregating materials procurement in local authorities.

- The establishment of a procurement organisation is another entity that thus makes operation more complex and also will develop its own goals for sustaining itself not just improving the system.
- The process diagram makes the actual operation appear trivial and so sets up a conflict with the system change agents
- The interdependence of the entities in the current operation is handled by informal adjustment (Crichton 1966) however, informal arrangements are not developed when a new system is operated relying exclusively on the formal procedures which are thus vulnerable.
- The various sub-systems have objectives which are not acknowledged in the process diagram, for example, the political desire to use local businesses in building work and the conflict with European procurement legislation, which can drive decisions and practices.
- The process assumes that everything works smoothly, however, there are no mechanisms for handling mistakes; thus mistakes are hidden until they become unavoidable.
- The costs of managing the process could be excessive particularly to overcome the cultural barriers thus making for poor economics.

Thus the soft systems approach suggested that these disturbances could be managed. It is would be important that any savings are made explicit and are assigned to the designers so that more work could be achieved for the same cost. At the same time this would lead to better work, principally from familiarity allowing everyone to get it right first time whilst improving health and safety, quality, reduction in conflict, and addressing the growing need for sustainability to be incorporated in thinking The political agenda would need to identify with the reduced costs to overcome accountability problems, the meeting of European rules, local employment and training concerns, local supply chain including support of SME’s, as well as local rivalry. The buy in from the contractors would be key so as to overcome their loss of aggregation with other contracts and their loss of flexibility in use of materials which allows them to overcome scheduling problems and specification errors. The centralised procurement organisation would become the repository for materials-use information which they could use to assist suppliers and obtain better prices. In addition they could help the designers to better understand the use of materials, life cycle and sustainability issues.

4. Discussion

This analysis was considered too simplistic as it assumed that the idea was generally a ‘good idea’ and that responses were genuinely responding to this. In fact, there was evidence that, both at the operational and managerial levels, there was a reluctance to discuss the ideas and many interviews took several attempts to accomplish with many being left un-conducted; this was never reported nor explained. Although the earlier study was correct at the formal level that process maps inadequately handle change, its discussion was simplistic in assuming that there was an acceptable solution. Boyd and Chinyio’s (2006) theory adds an important extra dimension to such discussions of change in complex clients and provides an explanation of the responses and reluctance to speak. The development of a ‘good idea’ is very similar to the development of a construction project which is unique and untried. The notion of a ‘good idea’ being at the centre of developments of construction practice requires that we understand the benefits that will be produced and the ways that this is going to be achieved. Good ideas tend to be firstly aspirational, thus formed by the client environment, and secondly, driven by the end values of the client. In Boyd and Chinyio’s (2006) analysis of building, the means and ends diagram (fig 2.) presents aspects that are known and those that are hidden, thus effectively unknown, and these operate together to determine outcomes and whether they are regarded as successful. Their analysis identified that there are two changes taking place: the building itself is being created and the organisation is being developed. Key to this paper is that improvement in the building process is also being initiated which adds a third level of change and further complicates the known rational processes but most importantly places much more in the unknown and emotional coping processes. It is this unknown and hidden side which governs an improvement project. The rational known side makes change appear simple and logical as it can be described and placed in, for example, a process flow diagram (Fig 3.).

The three domains Political, Managerial and Operational each has their own end achievements shown in Fig 2. some of which are known and explicit others are unknown and implicit. These end achievements partly come from the influences that dominate in fig 1: press, district auditor and framework agreements, which determine that the operational domain is concerned with ‘service delivery’; the managerial domain is concerned with ‘reducing costs’; and the political domain is concerned with explicit ‘political achievement’. However, the achievements create demands on all domains so for example the overarching agenda of accountability is shared by all but experienced differently. The managerial drive for reduced costs may be presented rationally as a drive for value but such euphemisms place the cost cutting realities of this in the unknowns. The ‘good idea’ of materials aggregation comes from this domain and driver. This cost cutting is also present in all domains but again experienced differently. The framework agreements whereby the local authority client has a long term contractual arrangement with a small number of contractors is the key deliverer of this end achievement. In the means and ends analysis, the heavy expectation for accountability determines that means are more important than ends. Thus there is a paradox that in LA there is a great impetus for lower costs through more efficient working but this is not compatible with the extreme requirements for accountability. The delivery of lower costs increases the operational risk which is part of the unknown thus making accountability difficult. In the operational domain, this gets translated as potential extra work and, even worse, there is the potential fear of jobs losses as more work is displaced to the supply chain.

The source of this ‘good idea’ was the managerial domain but the idea was actually born in its context of central government ‘consultancy’ to local authorities through a regional quango (quasi-autonomous non-governmental organisation funded by government with clear objectives but independently run) that favoured such initiatives. In the aftermath of the financial crisis not only were (and are) local authorities experiencing extreme budget cuts, quango’s were being removed. The one Regional Improvement and Efficiency Partnerships promoting collaborative operation has survived this in fact. At the same time there was tendering for major framework agreements which this idea could have been part of but the anticipated profits from the framework were much reduced thus as we will show such good idea remove a potential income stream. Although its roots are in the managerial domain, it was not the case that it was supported by this domain; this feeling is part of the hidden aspects of improvement. At the same time the other end values of service delivery and appeasement of the political domain might be put into question. At such time of major change, a ‘good idea’ however potentially advantageous appears extremely risky.

The political domain is much more complex. Clearly it is desirous of anything that lets the council save money or deliver more for its money. This they share with the managerial domain. However, the consequences are also political in that there will be complaints from voters that they are receiving less work from the council that they are paying tax to, but also that the economic development aspect of retaining council money in its locale helps to maintain the local economy. The later is not allowed by European legislation thus resides in the unknown. Their antithesis to the ‘good idea’ is further enhanced by this being a central government initiative and there is a continuing antagonism to the interference of central politics into local authorities.

The operational domain is well aware of the unknowns presented above whether these are articulated behind the scenes or merely sensed by tone and language. Again there is a desire for rational procedures to cover their end values: job security, procedures undertaken. Thus the responses are contradictory agreeing that there are opportunities but identifying numerous obvious problems.

The research project, to analyse the potential and effectiveness of the idea, was not in fact neutral as it was generated by the system; thus it was part of the means for parties to establish end achievements. What was required by the parties was a rational justification that the ‘good idea’ would not work. This answer could not be determined internally in the local authority because the aspects are undiscussable but had to be created by an externally respected organisation such as a University; this objective was clearly in the unknown. The University accessed both the rational and unknown sides in its stakeholder analyses and exposed the problems of operating an aggregation process. Thus in questioning the operation in the process diagram, it was possible for all parties to expose the potential process gaps in operation which would make the risks too high. The process diagram was too simplistic for real operation and merely establishing the ‘good idea’ as viable in the Known rational side of change but with potential pitfalls. This contradiction was exposed and presented as needing managing during implementation of the'good idea'. This would require maintaining accountability by planning everything beforehand and writing this down into procedural documents. Although the materials aggregation idea can be delivered in this way as evidenced by the process diagram, this is not sufficient to displace the unknown fears. Also in the LA clients environment was the construction industry itself which, through framework agreements, has been elevated to the managerial and operational domains. The private sector through framework agreements is a mechanism that can accommodate informal practices which can overcome problems; however, the public sector still does not trust the private sector in this way. In major change projects, the public sector roles within the managerial and operation domains will change and there is an additional fear that roles will be removed and jobs lost. The private sector do have a conflict of interest and were able to express this quite openly yet expressing their clear belief that it would not work because of the complexity. They were aware that they had influence over the cost reduction agenda and so supported this initiative but would not do this at the expense of their own economic survival.

5. Conclusion

The charge against current local authority procurement arrangements was made strongly by Cram (2010). We need therefore to re-examine the conditions that would have to be met in order to advance a 'good idea' in the public sector. To be successful a 'good idea' has to give advantages in the three domains Political, Managerial and Operational being aware that the benefits and dis-benefits will be different. The rational approach of using a process map to demonstrate systemic feasibility of the good idea is acceptable in the political and managerial domains but tends to simplify the operational domain thus not acknowledging this major risk. This needs to be recognised and mechanisms need to be put in place to allow the operational domain to change what is not working. The private sector can be a solution to change in the public sector as they are willing to accept the risks of the unknown and use informal means to make change work. However, mechanisms need to be found to maintain accountability and for the private sector to acquire benefits to their whole business. If such thought and organisation are not undertaken then change projects have a tendency to fail. The hidden side of the public sector is a powerful driver of outcomes. The ability of public sector to be explicit about what it wants to achieve is limited by regulation and a need for absolutely transparent accountability and this inability to articulate and discuss the issues prevents change. Crucially change in the public sector requires mechanisms to acknowledge hidden aspects in the known side.

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Client led innovation on megaprojects: novel low-energy cooling system case study in Singapore's SportsHub

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Abstract

Innovation requires a social governance environment that supports creativity. This research examines the governance context on megaprojects focussing on the client's role. We present the preliminary results of a case study client involved with the finance, design, build and operation of an innovative megaproject in Singapore. It is the largest sports facilities infrastructure Public-Private-Partnership (PPP) project in the world. It is also the largest and first PPP project in Singapore. PPP projects have multiple 'clients'. In this study the client network comprises the sports government agency responsible for setting up the project framework and the various PPP consortium stakeholders. A narrative analysis approach is employed drawing from the theory of cultural political economy and the concept of governmentality. The innovation explored in this paper is the creation and development of a low energy cooling system used in the National Stadium. The novel cooling system, which relies substantially on air movement, aims to provide a comfortable spectator environment in the country's challenging tropical climate. The innovation was initiated by the sports government agency, designed and developed by various interdisciplinary consultants and regulated by a government agency. The process in which the innovative cooling system was designed and developed to overcome conflicting priority agendas and achieve spectator comfort, sustainability objectives and regulatory approval is described in this paper. The findings indicate that although formalised structures and protocols were established for project coordination and communication decision-making was deeply influenced by informal communication embedded in multi-level networks. Power was constantly exercised and exchanged through various instruments of power including legitimate or position power, expert power and strategic games. The findings demonstrate that decision-making often occurred outside the pre-established structures and that the advancement of specific interests were facilitated by the political economic decisions of players in hierarchical positions of power. The social network analysis (SNA) method is proposed to demonstrate how the structure of networks influences the delivery of innovations such as the bowl cooling system on megaprojects.

Keywords: cultural political economy, governmentality, innovation, megaproject clients, social networks

1. Introduction and background

Megaprojects offer a range of opportunities for innovations to be implemented. The megaproject environment provides a fertile ground for innovations to take place since it is generally perceived that its success relies on signature design, high publicity of idealistic visions and grandeur project scale – key characteristics which call for innovative ideas and solutions (Boyd and Chinyio, 2006). Strategic decisions are made on megaprojects due to interests and motivations which are often not found on typical projects. Innovation requires a social governance environment that supports creativity. Clients play a critical role in driving the direction of megaprojects and in leading innovations (Nam and Tatum, 1997; Manley, 2006; Hartmann et al, 2008). It is thus important to understand the behaviour of clients in terms of the decisions made to support or suppress innovations on megaprojects.

This paper is positioned within an ongoing PhD study which aims to examine the governance context on megaprojects. The study explores the sophistication of megaproject clients who are often made up of representatives across multiple units or political groups in large-scale corporations or government agencies at the strategic, managerial and technical levels. Clients in the architectural, engineering and construction (AEC) sector particularly within the international context occupy a distinctly different position as the initiator of the construction supply chain. Therefore clients experience and respond to project matters based upon their own business environment and not the construction industry environment. There is a critical need to develop a greater understanding of the complex client decision-making environment within megaprojects. Past megaproject research (Priemus et al, 2008) focussing on the industry's role has very little relevance to the actual, daily activities of clients. Client priorities set the boundaries within which decisions affecting innovations, budgets, project organisational structure and team membership throughout the project lifecycle are made.

There has been relatively little recognition within the megaproject discourse of the power structure and social networks which affect client decision-making and the influence clients have in shaping the political economy of megaproject collaborative practice (Siva and London, 2010). Decision-making on construction projects is not wholly predetermined by contracts but instead often emerge from the use of power (Flybverg et al, 2003). There is often a discrepancy between the reality of power structures on projects and those formally prescribed by governing contracts (Loosemore, 1999). Although there is extensive literature on briefing and client participation methods seeking to guide clients as well as tools and methods to achieve successful megaprojects there is little theorising that links these issues coherently. There appears to be little research that approaches the problem from a cultural political economy perspective. This research seeks to address this gap by investigating the diverse forms of power, authority and subjectivity exercised in the client's everyday practices related to megaproject decision-making. We report early observations of one case study of a megaproject client in Singapore. The innovation explored in this paper is the design and development of a low energy bowl cooling system. The process in which the cooling system was designed and developed to overcome conflicting priority agendas and achieve regulatory approval is described. Prior to this an analytical model based upon cultural political economy theory and the concept of governmentality is proposed to frame the exploration of power relationships in relation to megaproject governance.

2. Cultural political economy

Cultural political economy (CPE) is defined as one which (Sayer, 2001, p. 688): "emphasises the lifeworld aspects of economic processes – identities, discourses, work cultures and the social and cultural embedding of economic activity, reversing the pattern of emphasis of conventional political economy with its concern for systems…[it] deals with the level of concrete and hence with firms, bureaucracies and households embedded in the relationships and meanings of the lifeworld…it should combine and "work up" abstractions of both system and lifeworld". The term lifeworld encompasses the informal aspects of life which is the product of the relation between embodied actors and the cultures into which they are socialised. Systems are the formalised rationalities which have a logic and momentum of their own, going beyond the subjective experience of actors to routinise or govern specific actions through signals and rules such as prices, money, bureaucratic processes and procedures (Sayer, 2001). A key characteristic of CPE is its examination of the "embedded" nature of economic action in terms of how they are set within social relations and cultural contexts that impact upon those economic processes (Sayer, 2001). CPE analysis offers a way of demonstrating how the advancement of specific interests is facilitated by the political economic decisions of key players in positions of power (Anderson, 2004).

The CPE of megaproject environments is composed of power relations among a diverse range of stakeholders such as clients, project managers, architects, users, property owners, financiers, regulatory bodies, local communities – each attributing their own value at various stages of a project. A range of activities and processes are typically conducted particularly on such large undertakings as megaprojects including briefing, stakeholder management and community participation, aimed at aligning project objectives and stakeholder requirements. Such efforts, however, may not prevent stakeholders from pursuing their self-interests. Power differentials on projects cause stakeholders to employ various strategies or tactics to place them in positions of advantage. A series of important questions to this research follows: *How do ideas get disseminated, accepted or rejected on megaprojects? How is power created, nurtured and employed on megaprojects? What other forms of power are available for various stakeholders on megaprojects? How do responsible AEC professionals who can contribute to the quality of built environments enhance their power on projects to improve project performance?*

3. Governmentality

The concept of *governmentality*, developed by Foucault (1979) in the 1970s through his investigations of political power offers a useful language for exploring both the macro spaces of megaproject governance frameworks as well as the confined locales of client workplaces and the everyday practices and networks where various forms of power come to be created, distributed and exercised. Foucault (1993) defined government as "the conduct of conduct", which is a form of activity seeking to shape or guide the actions of others through the exercise of various techniques (Christie, 1982) While the word *government* may imply a strictly political meaning today, Foucault (1993) placed the problem of government in a more general context embracing philosophical, religious, medical and familial sites (Lemke, 2008). By widening the context of governmentality the conception of “governmental authorities” is extended to include families, churches, experts, professions and all the different powers engaging in “the conduct of conduct”.

The concept of governmentality deepens our understanding of power by demonstrating that power not only resides at the centre of a single body but is also present in diverse locales (Garland, 1997; Rose et al, 2009). Power is visible in both everyday life and institutions (Rose and Miller, 1992; Donzelot, 1979). It should not be assumed that the mere existence of a structure within a network implies an acceptance or implementation by members. Whilst such formalised structures appear highly visible, there are also other less visible relationships and dealings occurring where power is constantly exercised and exchanged. Foucault traced a movement between the 16th and the 18th century and identified two distinct rationalities of governing practiced by state and other agencies: the sovereign and family model, which he positioned at opposite ends of a spectrum. Whilst the former was concerned with abstract and rigid ways of thinking about power the latter model was devoted to matters to enrich the small family unit (Foucault, 1979). Distinctly, he identified a third form of rationality which took place from mid 18th century onwards, governmentality, which viewed power in terms of its populations with its own realities, characteristics and requirements; independent of government yet at the same time requiring government intervention (Rose et al, 2009). These populations cannot simply be controlled by implementation of the law or programs nor be thought of as a type of extended family. Foucault highlighted that populations have their own characteristics which need to be understood through specific knowledges and it is through these emergent understandings that the “art of governing” is formulated.

The practices within the social realm of government are undertaken in their complex relations to the various ways in which “truth” is conceived by the different agents (Dean, 2010). Within the context of megaproject decision-making, how clients govern themselves and others relies on what they see to be ‘true’ about who they are which is in turn influenced by the rich and complex social networks, cultural norms and social obligations they are embedded within. It is thus important to capture what rationalities of governing are implicit in the client’s practices and how they relate to those of project team members working on megaprojects. How do clients who are at the top of the governance structure of megaproject decision-making understand their powers and the impact of their practices? Governmentality should not be viewed as a theory of power or governance. Instead “it asks particular questions of the phenomena that it seeks to understand, questions amenable to precise answers through empirical inquiry” (Rose et al, 2009, p. 3). The governmentality perspective seeks to pose questions relating to power without attempting to prescribe a set of principles or ideology for governing others and oneself. In doing so, we are practising a form of criticism which makes explicit the taken-for-granted character of these practices (Foucault, 1988) in terms of how clients govern and are governed and in the ways by which they do. Through this we open up for analysis various forms of strategic games in terms of contestations and negotiations between stakeholders on megaprojects.

4. RESEARCH METHODS

This study employs a case study strategy through the use of the narrative inquiry (NI) and social network analysis (SNA) methods for collecting and analysing empirical material. Firstly the NI approach allows for an investigation of how megaprojects are shaped within the structure of power relations, that is, the *nature* of power relations. It seeks to uncover stories which highlight changes in decision-making brought about by contact between stakeholders. NI enables a systematic study of the key events within the client's decision-making experience to connect and see the consequences of those events and actions. Secondly SNA is used to identify the interdependency between stakeholders, that is, the *structure* of power relations. SNA's main point of difference from other types of analysis of social phenomena is its focus on the *structure* of relationships between actors instead of the *attributes* of actors (Davies, 2009). Diversity in methods and tools for data collection and analysis is critical in the production of accurate and reliable representations of social reality. The methodological value of the social network perspective in the analysis of the cultural political economy of megaprojects lies in its ability to complement the qualitative method of NI to enhance understanding and provide interdependent explanations of the power structures underpinning client decision-making.

This paper reports early observations made from one case study of a megaproject client in relation to the design and development of an innovative bowl cooling system. This preliminary analysis sought to test initial assumptions and to refine the data collection tool made up of an interview schedule and questionnaire. Sixteen interviews have been conducted to date with a range of participants (refer to Table 1). In keeping with the narrative inquiry approach, the interview instrument was designed to be broad and open-ended to provide participants the opportunity to express themselves in their own words without being influenced by suggestions from the researcher as well as to invite participants to tell their own stories. Participants were asked questions in relation to three broad areas: their role in the organisation and on the megaproject; stories in relation to project issues experienced and how decisions were made to resolve issues and their relationship with other project stakeholders. The observations reported in this paper are the result of the preliminary analysis of the interviews. Stories told by individual participants relating to the design and development of the innovative bowl cooling system were identified and "open coding" was conducted based on the loose association of themes and concepts. Following this axial coding was conducted involving the arrangement of data according to dominant themes that emerged. The next stage of analysis will involve detailed narrative analysis of the stories, and then followed by the administration of a questionnaire to map the structure of power relations through the SNA approach.

Table 1: Interview participants

Participant	*Organisation*	*Role*
P1	*Singapore Sports Council*	*Project Director, SportsHub*
P2	*Singapore Sports Council*	*Deputy Director, Operations & Programming, SportsHub*
P3	*Singapore Sports Council*	*Project Director (former), SportsHub*
	Venue operator	*Asst General Manager*
P4	*Design & Build contractor*	*Contracts Director*
P5	*Design & Build contractor*	*Sr Design Manager*
P6	*Architecture firm*	*Associate Director*
P7	*Special purpose vehicle*	*Chief Executive Officer*

P8	*Special Purpose Vehicle*	*Chief Operations Officer*
P9	*Design & Build contractor*	*Technical Director*
P10	*Singapore Sports Council*	*Sr Manager & Head, Design & Technical, SportsHub*
P11	*Singapore Sports Council*	*Sr Director, Sports Pathway Development, Sports Development Group*
P12	*Singapore Sports Council*	*Asst Director, Events Portfolio Management, Sports Business*
P13	*Singapore Sports Council*	*Project Director (former), Sports Hub*
P14	*Singapore Sports Council*	*Sr Executive, Operations & Programming, SportsHub*
P15	*Singapore Sports Council*	*Sr Manager, Contract Compliance, SportsHub*
P16	*Sports Architecture Firm*	*Sr Associate*

5. RESULTS

The case study is a 1.33 billion SGD multi-use, multi-sport and entertainment complex in Singapore. The project seeks to encourage large numbers of people to adopt and pursue sports and to draw international events to its world class facilities, which is part of the government's broader vision of creating a thriving sports, entertainment and lifestyle ecosystem (Sporting Singapore, 2001). The project involves the demolition of an existing National Stadium and the construction of new buildings including a national stadium, multi purpose indoor arena, aquatic centre, water sports centre, Singapore information and resource centre, sports promenade and commercial space/retail mall. It also incorporates the use of an existing multi purpose indoor arena. It is the largest sports facilities infrastructure Public-Private-Partnership (PPP) project in the world (SSC, 2012). The project is also the first PPP project in Singapore. A Special Purpose Vehicle (SPV), SportsHub Private Limited, was formed to finance, design, build and operate the facility in partnership with the Singapore Sports Council (SSC) over a 25-year period. The SPV invests in equity and utilises bank debt financing to build the facilities (Singapore Parliament Report, 2009). Upon completion of the contract the facility will be handed over to the SSC.

PPP projects have multiple 'clients'. In this study the client network comprises the sports government agency responsible for setting up the project framework, SSC, and the various PPP consortium partners which have varying levels of involvement (refer to Figure 1 in appendix). All the PPP partners are bound to the Project Agreement and the various protocols set out in the Interface Agreement. Formalised structures and protocols have clearly been established by the SSC and SPV for project coordination which are aimed at achieving control of accountability of decision-making as well as respecting the roles and boundaries of various parties. Indeed these formalised structures and protocols offer clear traceability in terms of lines of official document exchange between project stakeholders. However, what these official documents fail to record are the informal negotiations and dealings occurring in multi-level networks whereby power is constantly exchanged and exercised. Past research has identified that these informal networks and communications are equally, if not more, important than pre-established structures (De Blois et al, 2011). Preliminary analysis of the SportsHub case study supports these past findings in relation to two key areas: indirect or non-expert participants can sometimes act informally as client representatives and influence the direction of projects; and informal communication and decision-making are often made outside pre-established structures (Siva and London, in press).

Given the significance of the SportsHub project a high level of interest was received from various government agencies including the Building and Construction Authority, Urban Redevelopment Authority, Land and Traffic Authority and National Security agency which were informally drawn into the project process thereby influencing how decisions were made on several occasions. Different regulatory bodies were able to drive the direction of the project to support or suppress innovations. To demonstrate this in greater detail the following section outlines the process involved in the creation and development of an innovative low energy bowl cooling system whereby decisions were often made outside the pre-established structures and the advancement of specific interests were facilitated by the political economic decisions of players in positions of power.

5.1 Low energy bowl cooling system innovation

The centrepiece of the SportsHub is the National Stadium which is a 55,000 spectator, multi-sport stadium featuring a retractable roof, configurable arena seating and an innovative bowl cooling system. The novel cooling system, which relies substantially on air movement aims to provide a comfortable spectator environment in the country's challenging tropical climate. The system provides cooling by treating the microclimate immediately around the spectator rather than the entire volume of the semi-enclosed stadium thus significantly reducing energy usage. The cooling system is aligned with the consortium's contractual commitment to SSC to achieve a GreenMark GoldPlus award, which is the second highest ranking achievable under the country's ranking system for evaluating environmental performance of buildings. At the time of the interviews the design team was undergoing the final review process with the government body governing building and construction regulations in Singapore, the Building and Construction Authority (BCA) prior to being awarded the GreenMark GoldPlus. The interview participants explained that the lengthy process they underwent to arrive at this milestone was one characterised by uncertainty and complexity. The design manager explained that a key challenge was the need to incorporate the needs of not only the formal client, the SSC, but also those of the BCA:

> "…we had instructions from one part of government – and that necessarily creating a PR problem for another part of government" (Senior Design Manager, Design and Build contractor)

Shortly after finalisation of the Project Agreement in 2010, the BCA expressed concern regarding the bowl cooling scheme. BCA has been actively discouraging the spillage of air conditioning from indoor spaces to outdoors, both through improved regulation and enforcement, and advised that they were considering further retroactive regulation to control this practice. While the bowl cooling system is not air conditioning *per se* – unlike air conditioning, no dehumidification is provided and a substantial part of the spectator comfort is created by air movement as opposed to air temperature – BCA expressed concern that the bowl cooling system may be perceived as air conditioning by the general public. Providing regulatory approval for the use of the bowl cooling system may thus be seen as a precedent for provision of air conditioning to outdoor spaces thereby undermining BCA's efforts to eliminate this unsustainable practice. Therefore at one stage the bowl cooling system was, as described by the design manager, "going off the rails" and "up in the air" whereby there was little clarity in terms of whether it was allowed for use in the National Stadium given that it was seen as an illegal practice by the BCA. For months the design team found themselves defending the scheme to the BCA by presenting a series of arguments from a technical perspective in terms of the efficiency of the scheme, which unfortunately was not accepted during the initial stages. The design team's frustrations are reflected in the following quotes:

> "we could've arrived at a solution which would've used our modelling and calculations 2 or 3 times as much energy…but that generally wasn't accepted…There are comparisons to other projects where semi outdoor spaces have been cooled and the BCA hasn't allowed that and that is part of the reason why this has become sensitive issue." (Senior Associate, Sports Architecture Design Firm)

> "What we're doing is the most efficient thing but from their point of view not to hinder this other law it'll be better if we built an enclosed dome and use four times the energy…we didn't anticipate this…political wrinkle" (Senior design manager, Design and Build contractor).

The design team's frustrations seemed to stem from their inability to put forward an argument in support of the bowl cooling system based on a rational and technical perspective. Through extensive computer modeling and calculations the design team presented what they worked out to be "the most efficient" means of providing spectator comfort. However, it was felt that a less innovative scheme using "four times the energy" would have been better received by the authorities simply because it would not create a public relations problem for the BCA as the bowl cooling system presumably would. Eventually though the BCA provided clearance of the scheme from a regulatory point of view. The design manager indicated that the SSC played a critical role in facilitating the approval process:

> "SSC was working behind the scenes to work through that. They weren't involved with the day-to-day technical aspects but we keep them very aware and they do kind of help go to government departments and help smooth things out" (Senior design manager, Design and Build Contractor)

The Senior Manager from the SSC who leads the design and technical sub-division within the SSC's SportsHub division confirmed that the SSC were involved in a number of informal negotiations with the BCA to help achieve regulatory approval for the bowl cooling system. Given the innovative nature of the cooling system the Senior Manager indicated that there was a need for the local authorities to be less rigid about complying strictly to local guidelines and to treat and assess the system based on a separate set of criteria or conditions which needed to be negotiated:

> "BCA came to SSC, "is this really part of the client requirement?" and we said "yes…sometimes when…they [design team] need some help…SSC being one of the government agencies can…lend them some support…even in parallel we'll go behind them and talk to the agency like in this case… that's why we were able to convince them …But of course we had to pre-agree with them…on how we can operate it (Senior Manager and Head of Design and Technical – SportsHub, SSC)

Clearly the discussions between the SSC and BCA influenced the ultimate outcome of the bowl cooling system approval process. However the Senior Manager also pointed out that the efforts of the design team in providing quality information to BCA in support of the innovation also helped to facilitate the process. According to the Senior Associate from the Sports Architecture firm the type of information as well as the frequency and timing within which information was provided by the design team to the BCA was something which was well thought through and organised:

> "We have to do a little bit of talking about what the expectations of what the authority is going to want to see…you have to continually manage that to get people recognising that we've got this "package A" which we use for the authority and we've got this package B or C or D in some areas which is already advanced to a slightly different form" (Senior Associate, Sports Architecture Firm)

Furthermore in order to ensure that the right type of information was obtained from the various parties within the design team the Senior Associate indicated that conversations were often "held quietly" to "attune" others to "the message they want to hand over to the authority". Key people in positions of power were also clearly recognised as those who can help achieve the desired outcome:

> "some conversations are held quietly to try and prepare to get someone else ready to be bringing the information out in the form which is going to work for everybody…We can use people like XXX…to help our cause…he is a very effective operator in that position" (Senior Associate, Sports Architecture firm).

After the BCA granted regulatory approval for the use of the bowl cooling system further negotiations were undertaken to agree on how the system will be operated. During an initial assessment of the design team's application for the GreenMark GoldPlus award the BCA advised that in order for the SportsHub to achieve a GoldPlus award, the energy usage of the bowl cooling system must be 100% offset by renewable or waste-generated energy sources. The issue of a major project associated with the Singapore government creating a public relations problem for BCA's enforcement efforts to stamp out purposeful spillage of air conditioning to the outdoors is thus resolved by the ability to advise the public that energy used for the bowl cooling system is completely offset by renewable energy. Following this the design team and consortium partners spent considerable amount of time exploring the means of financing and installing sufficient PV cells to offset the power anticipated to be consumed by the bowl cooling system. Because the cost of this installation was not anticipated at the time of the contract preparation, schemes by which third party investors purchase the PV installation and sell back the power generated are currently under investigation.

5.2 Instruments of power

The problem of conflicting priority agendas in relation to the bowl cooling system was eventually overcome but not without a series of negotiations between stakeholders. Clearly, the negotiations and relationships are not reflected in the formal structures prescribed in the contractual agreement. These informal networks and various forms of instruments of power, however, have been demonstrated to have a significant impact on how the project was shaped in relation to the design and development of the cooling system. The process in which the cooling system was initiated, developed and accepted by the regulatory authority highlights how the actions of stakeholders were deeply embedded in the hidden exercise of power. A number of emerging themes can be observed including:

- the use of legitimate or position power appeared to be more effective than expert power in achieving regulatory approval for the bowl cooling system;

- the effectiveness of legitimate or position power is increased on megaprojects and strategic release of appropriate information and

- strategic games in the use of key people in positions of power to facilitate the approval process.

Legitimacy or position power was demonstrated to be an important form of power whereby the SSC, by virtue of being a government agency, were able to exercise their invisible rights to engage in negotiations with the BCA on the same level of authority. Approval for the bowl cooling system was only provided following SSC's private discussions with the BCA. Even though the design team had spent considerable amount of time defending the scheme the BCA appeared to place much more weight in SSC's justifications of the system. There appeared to be a degree of trust shared between government agencies in Singapore which is demonstrated by how the BCA approached SSC to seek confirmation that the bowl cooling system was a part of the brief requirements even though the design team had already indicated this. The process in which the bowl cooling system achieved regulatory approval demonstrates that the exercise of political power can overrule rationality in certain situations. The design team's expert power in presenting an innovative and efficient system was less effective than the SSC's legitimate power related to their position within the network of government agencies. This is of course not to say that stakeholders should ignore the environmental, social, moral and professional arguments in support of their respective positions. Rather a strict adherence to rationality and logic alone without adequate acknowledgement and understanding of other forms of power will unlikely lead to successful outcomes as the case of the bowl cooling system has shown. It is thus important to understand the various strategic games stakeholders employ in the exercise of power in megaproject decision-making and how this influences the delivery of innovations.

The very nature of an innovation necessitates a change from the norm whereby it is unlikely that project innovations will comply with existing codes or regulations. Given that megaprojects are characterised by innovations, code compliance and achieving regulatory approvals can often pose as a key challenge. The design team found themselves in a difficult position of getting the bowl cooling system accepted by the local authorities even though the efficiency of the system far exceeded the basic requirements of the building regulations and codes. The provision of regulatory approval for innovations on megaprojects thus can become a grey area with little clarity in terms of what is required and the process in which project participants need to comply with in order to achieve successful outcomes. This lack of clarity gives rise to a situation where those responsible for providing regulatory approvals gain increased power to dictate and impose their requirements upon other stakeholders who in turn become highly vulnerable. Ultimately the drive to successfully deliver project innovations falls onto the responsibility of key stakeholders within the project team. In the case of the bowl cooling system there was a strong desire by the client network comprising the formal client and design team to implement the bowl cooling system despite the challenges encountered. The power domination of the regulatory context associated with the approval of innovations in Singapore does not appear to be a conducive environment for innovations to be successfully delivered and is perhaps worthy of further exploration.

The design team found that they needed to respond to not only the requirements of the ultimate client, the SSC but also the BCA. In dealing with the authorities the design team clearly understood the need to adopt a considered approach in presenting the type of information which is aligned with the expectations of the authorities. Furthermore in order to ensure that the right type of information was obtained from the various parties within the design team there was clear recognition of specific people who were felt to be in influential positions to facilitate the process. The use of certain relationships and networks can thus be more effective than others depending on situational needs. This demonstrates that there are ways in which those in weaker positions of power can achieve stronger positions through smart linkages. This also demonstrates that despite the importance of organisational and project structures in formalising communication flows and coordination, how work is carried out on a daily basis tends to have more to do with the informal relationships and interactions between members within and across organisations as they strategically assess and “work out deals” to better achieve what they require.

6. SUMMARY AND FURTHER RESEARCH

This paper described an analytical model which was developed based upon cultural political economy theory and the concept of governmentality to examine megaproject client governance and its relationship with the delivery of innovations. The early observations of the case study of the Singapore SportsHub in relation to the innovative bowl cooling system confirmed initial assumptions made that although formalised protocols were established for project communication and coordination decisions were often made outside of the pre-established structures. Furthermore decision-making was influenced by informal communication embedded in multiple levels of social networks comprising various stakeholders in positions of power who at times act as “clients”. These observations highlight the significant influence of the structure of networks on decision-making and the delivery of innovations on megaprojects. Megaproject decision-making is thus a network problem requiring an understanding of social structures. Different types and forms of social networks may be essential for achieving different project outcomes in relation to the delivery of innovations at various stages of project decision-making. The structure of social networks embedded in the multilevel environment in which client decision-making is undertaken may contribute towards understanding the way decisions and actions occurring at the confined locales of client workplaces can impact on project outcomes at higher levels. However, to date there is still little known in terms of the nature and structure of power relations in megaproject client decision-making where various forms of power come to be created, distributed and exercised. Therefore the next stage of analysis involves a social network mapping of the informal links between stakeholders to highlight how the structure of power relations influences decision-making and in turn the delivery of innovations on megaprojects.

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8. APPENDIX

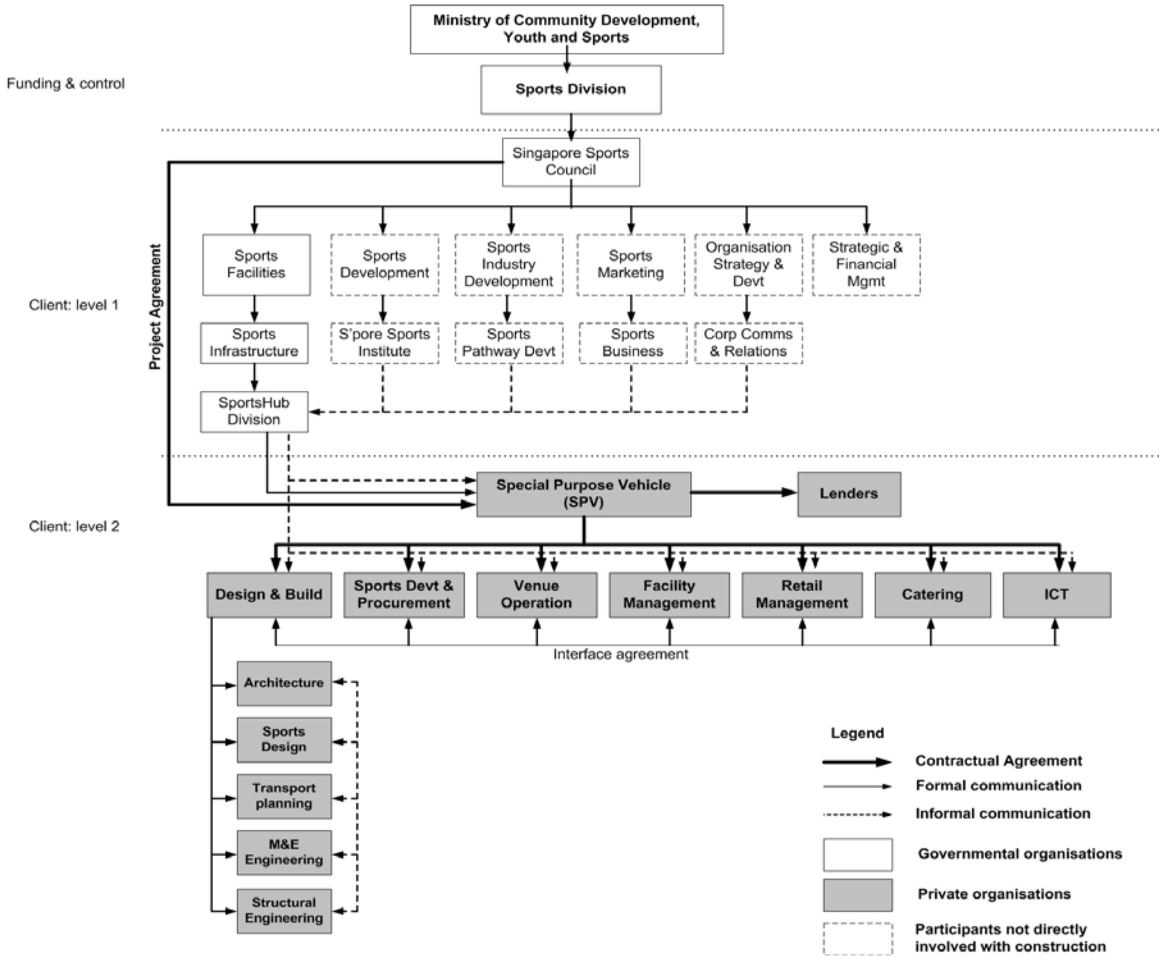

Figure 1: PPP Structure of the SportsHub project (Siva and London, in press)

Clients as supply chain managers: prominence, path lengths, knowledge and innovation

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Abstract

The paper presents the findings of some primary research which used Social Network Analysis (SNA) to investigate the actor roles and network configurations which client organisations initiate and maintain in the project coalition systems with which they link in order to build or develop.

Projects, their structures and systems, can be studied at a number of levels of abstraction. Most would agree, however, that the pursuit of cost, time and quality rarely deliver 'customer delight'. The use of SNA enables the study of a range of transaction sets and relationships, providing an analysis of the systems with the potential to deliver value and innovation to clients and end-users. This research draws on a small group of transaction sets and relationships which give insights into the way in which the knowledgeable and experienced client achieves improvements in value creation and innovation compared to other client types, using procurement methods which do not provide client prominence and connectivity.

The findings of the research focus upon the prominence of the knowledgeable and experienced clients in networks during production project phases - short path lengths enabling innovation and knowledge transfer. The maintenance of these network configurations obviates the need for complex and/or contiguous financial incentive arrangements.

Keywords: Social Network Analysis, transaction sets, innovation, knowledge, contractual relationships

1. Introduction

This paper provides a very brief overview of a framework used to analyse collaborative relationships in construction and their effects on projects. Part of the data gathered relating to contractual relationships is presented here along with some of the innovations achieved through the client placing themselves in a highly central network position in relation to the project coalition.

2. Projects, structures and systems

In the past we have drawn upon a range of methods to analyse and model systems in projects. These approaches can be classified into three groups (Pryke, 2005 and Pryke, 2012):

- Task Dependency Analysis (critical path analysis, for example)
- Structural Analysis (use of management structures, for example)
- Process Mapping (cognitive mapping, for example)

Task dependency analysis essentially relied upon breaking down the project into a list of activities that needed to be performed to complete the project. The Critical Path Analysis (CPA) diagram arranges the elements of the project in a sequence that essentially reflects the shortest possible programme of work given that certain activities must be completed before others can commence. The *critical path* links all interdependent, sequential events and, in this way, demonstrates the shortest possible programme that properly reflects the interdependence of the project activities. Structural analysis in the traditional sense provides some sort of 'organogram' or family tree showing the project or organisational actor roles and one type of relationship between them. These organograms focus upon authority relationships between role-holding actors. Curtis et al (1991) and Edkins (1998) employed cognitive mapping to represent client objectives in the project environment, Edkins mapping at a detailed level relating to specific building sub-elements.

Walker (2006) identified the need for a number of issues to be dealt with in the analysis and design of organisational structures: - the operating and managing systems, relationships, (actor) roles, position of the decision points and their status and the contribution of people to each decision and their relationships in arriving at decisions.

Despite the existence of these methods and repeated overtures from those calling for reform within the construction industry (Simon Report (Min. of Works, 1944), Emmerson Report of 1962 (Min. of Works, 1962), Banwell Report (Min. of PBW, 1964) and Wood Report (Wood, 1975), among others), little progress was made with what Rimmer (cited in Latham, 1994) referred to as 'customer delight'. At one level it might be argued that the construction industry is content with monitoring a range of basic performance metrics relating to the 'iron triangle' (see Morris and Pinto, 2004 cf Atkinson, 1999). Contract condition in common use utilise reward and punishment systems that relate to these basic performance metrics.

3. Theoretical Framework

The construction of a building can be regarded as a complex, information dependent, prototype production process where conception, design and production phases are compressed, concurrent and highly interdependent, in an environment where there exists an unusually large number of internal and external uncertainties (Pryke, 2012). Existing methods of classification and analysis of project management systems and their representation have been inadequate in the context of the complex and transient organisational forms seen in major and/or complex projects.

Commons suggested that the *transaction* should provide the most appropriate unit of investigation in the analysis of the activities of firms (Commons, 1961). Williamson's work effectively combined the behavioural assumptions in Simon's work (see for example, Simon, 1955; Newell and Simon, 1972) with Coase's discussion of the causes of transaction costs and why transactions occur within markets or firms (Coase, 1993). The concept of the *transaction* is important to this discussion.

> *"A transaction occurs when a good or service is transferred across a technologically separable interface….. (Williamson, 1981:552)*

One of the underlying premises of transaction cost theory is that the *properties of the transactions* determine the *governance structure* (Williamson, 1985). Winch (2000) observed that partnering and the reform of standard contracts focus on transaction governance, and simply by reducing transaction costs, important gains can be made. Transactions and their governance are affected by a wide variety of uncertainties in the transaction environment, requiring governance systems providing some level of adaptability. This paper investigates a particular type of governance structures used by some developers to improve their prominence in the management of Tier 2 contractors, to shorten links with these actors and through these short path lengths to improve knowledge transfer and collaborative innovation.

3.1 A contract theory of the firm

Both transaction costs and agency theories share the principle of *contract*. Williamson refers to "contractual man" (Williamson, 1985) and discusses *relational contracting*, which is particularly relevant to the concept of partnering. In agency theory, contracts are a central concept and the organisation is conceptualised as a *nexus of contracts* (Fama and Jensen, 1983, cited in Reve, 1990). The major organisational task, from the agency theorist's viewpoint, becomes the design of incentive systems to avoid efficiency losses. Aoki *et al* (1990) draw together the contributions of transaction cost economics and agency theory, along with some contract ideas from sociology and law, to propose a contract theory of the firm. These contracts are categorised as internal and external contracts. Reve (1990) posits that, from an efficiency point of view, internal contracts should deal with core skills such as technological know-how and marketing knowledge; external contracts should deal with "complementary skills" and interorganisational incentives.

The contracting framework takes the *transaction* as the basic unit of analysis. Reve (1990) deals with the difficulties associated with the identification and isolation of individual transactions by proposing that *sets* be analysed. The effective study and analysis of construction coalitions requires individual transactions to be grouped - this arises out of the iterative and complex nature of construction activity.

3.2 Transaction sets

Reve applies the contract theory of the firm to the construction industry and identifies five value-adding activities, which constitute sets of transactions. These are: Concept, Design, Project Management, Construction and Service (Reve, 1990). The transaction sets used in the case studies presented here included information exchange networks related to: Client Briefing, Design, Progress and Financial Management. Winch (1989), however, described the construction project as a *temporary project coalition* and observed that earlier work (Tavistock Institute, 1966, for example) failed to provide any analysis of the implications of *contracting relationships* for communications in the industry.

Apart from the smallest of single-trade work packages, most construction contracts are complex due to the high levels of incompleteness and corresponding uncertainty. Recent research by Walker and Pryke (2009, 2010) has proposed certain testable propositions relating to incompleteness in construction contracts. The quantification of transaction costs has previously proved fairly elusive.

So the production of a building by the temporary construction project coalition can be conceptualised as a process comprising a nexus of contracts or treaties, the governance of which can be analysed using observation of sets of transactions associated which each of the main functions of project management activity. The analysis of the implications of contracting relationships upon communications and the effectiveness of incentives within the context of the construction project were studied using social network analysis (SNA).

3.3 A model for analysis

So far we have seen that over the last 3 decades the construction industry has evolved procurement and management systems that lie somewhere between the market and hierarchy models, with packages of work procured, possibly, through a market driven approach but subsequently managed in a hierarchical context within the environment of the *temporary project coalition.* Stinchcombe (1990) observes that complex contracts are written in such a way that they achieve hierarchical effects. Specifically, these complex contracts: "Specify authority systems, deal with incentives between project actors, administer a pricing system, make provision for conflict resolution and have “standard operating procedures” (Stinchcombe, 1990).

There are powerful arguments for regarding the construction project as a network of firms, governed by a nexus of treaties, working together for the purpose of a delivering a project. Increasingly, these networks have value over a programme of projects. Furthermore, some would argue that these networks are the source of innovation, whether aimed at increasing market share and profitability, or as a strategy for survival in difficult trading conditions (see Pryke, 2009, 2009a). The case study material presented here deals, alongside other network analysis studies, with the identification of intracoalition relationships and their associated transactions, contrasting traditional approaches to procurement with *extra-contractual* relationships enabling partnering and supply chain management approaches to flourish. The major reports into the construction industry (see above) established, inter alia, that a *lack of clarity in the roles* of the project actors, and the *relationships* between them, has been a recurring theme for construction.

3.4 Networks of actor relationships

So how might we classify and analyse systems used in projects? In particular, how might we, for example, quantify the difference between traditional procurement and more collaborative approaches? In order to capture the main features of collaborative procurement systems evolving during the last two decades it is instructive to gather data relating to the following sets of transactions: -

- Contractual conditions – we need to represent the firms involved in the project coalition and each firm's dyadic relationship with other firms within the project.

- Performance incentives – the use of collaborative approaches might shift the emphasis of governance away from an emphasis on contractual matters.

- Information exchange networks – the analysis inter-firm (or intracoalition) information exchanges within the project team reflects the impact that the evolution of collaborative relationships-based procurement has on roles and responsibilities.

It is suggested that the alignment of performance incentives and information exchange patterns with the contractual conditions provides a sense of the extent to which a procurement method is transitional. Temporary *governance modifiers* (for example, the use of a partnering charter alongside a standard form of building contract) are eventually assimilated into the standard conditions of contract. At this point the form of procurement has *matured.* In some cases procurement systems do not reach maturity, either because the original concept was flawed, or because the context in which the contract is intended to operate has changed.

The premise for this paper is that it is the effective management of relationships within the extended supply chain that is important in the delivery of projects that delight clients and stakeholders. Contractual arrangements that reduce contractual hierarchy improve knowledge transfer, enable innovation (and reduce contractual disputes - see Walker and Pryke, 2009, 2010).

4. Why SNA?

4.1 Why choose social network analysis?

Nohria and Eccles (1992) identified five reasons for adopting a network perspective when looking at (not necessarily construction) organisations. These comprise, in summary:-

- All organisations are social networks and therefore need to be addressed and analysed in terms of a set of nodes linked by social relationships.

- The environment in which an organisation operates might be viewed as a network of other organisations. Network analysts recognise that the most significant elements of an organisation's environment are the other organisations with which they must transact.

- Organisations are suspended in multiple, complex, overlapping webs of relationships and we are unlikely to see the overall pattern from one organisation.

- Actions (attitudes and behaviour) of actors in organisations can best be explained in terms of their position within networks of relationships. We must therefore consider an actor's position and the attributes of that position to gain a full insight into their actions.

- The comparative analysis of organisations must take into account their network characteristics. Centrality, for example, is a measure of the average degree of asymmetry in relationships within an organisation or project, and the extent to which decision rights are concentrated among few individuals.

Nohria and Eccles (1992) do not distinguish between two quite different types of actors; these are *individuals* and *firms*. Construction coalitions, involve a range of actor roles being fulfilled by individuals and a range of actor roles fulfilled by firms. The decision about whether to study inter-firm or *intra-firm, intra-coalition, interpersonal* relationships is an important first step in starting out in SNA-based research. Data presented here reflect role - holding actors which are firms.

4.2 Problems associated with the use of SNA in construction research?

The following represents some frequently asked questions about SNA, with responses in italic.

- It is a quantitative method used within an interpretative context (Loosemore, 1998). *SNA is not alone in relation to this criticism; a similar criticism could be made of most, if not all, statistical analysis. SNA provides very rich data when combined with qualitative material relating to project and actor characteristics.*

- SNA deals with analysis but does not always provide causality. *Once again, this is not peculiar to SNA. Causality - in terms of its establishment, must, almost inevitably, be a problem wherever the analysis of essentially unique projects is concerned.*

- SNA is relatively complex in terms of both theoretical and mathematical bases; complexity creates a barrier to entry – *Yes SNA is complex both theoretically and as a method. This explains the relatively small number of individuals with expertise in SNA, related to the construction area.*

- It is necessary to classify each network very precisely and this can lead to a potentially large number of different relationships between a given group of actors - leading to large volume of data. *Agreed - it is not useful to look at unclassified communications between design team members, for example. We need to understand the mode of communication and the purpose of the interaction. Frequency and perceived importance on the part of the sender and receiver, help to create many finely classified networks representing communications between our team.*

- Sampling is not effective or appropriate with networks. It follows that a 100 percent response from project actors is essential. *Agreed - gaining the support of the client and having the client express this support is important.*

5. Research Findings

The research involved four construction projects: Essex, Uxbridge, Aldershot and Slough. Network data was gathered during the mid-third of the execution phase of the projects. Fig 1 shows the contractual networks for these four projects. All four client organisations were regular clients of the UK construction industry. The Essex and Uxbridge projects used traditional procurement systems and involved the public and private sectors respectively. The Aldershot and Slough projects used procurement approaches involving collaborative relationships to facilitate supply chain management activity over a range of projects; public and private sectors, respectively. Only the Slough project exhibited evidence of innovation in systems and processes.

5.1 What do the sociograms reveal?

The Essex sociogram reveals a two-cluster hierarchy of contractual relationships; the upper cluster representing the client (ECC) and its advisers; the lower cluster represents the contractor (F) and its sub-contractors. The Uxbridge sociogram is a three-cluster hierarchy of contractual relationships. The cluster around XRX represents the tenant of the office development. PPL is the development vehicle for the project with its consultants. NWH is the Tier 1 contractor surrounded by its sub-contractors.

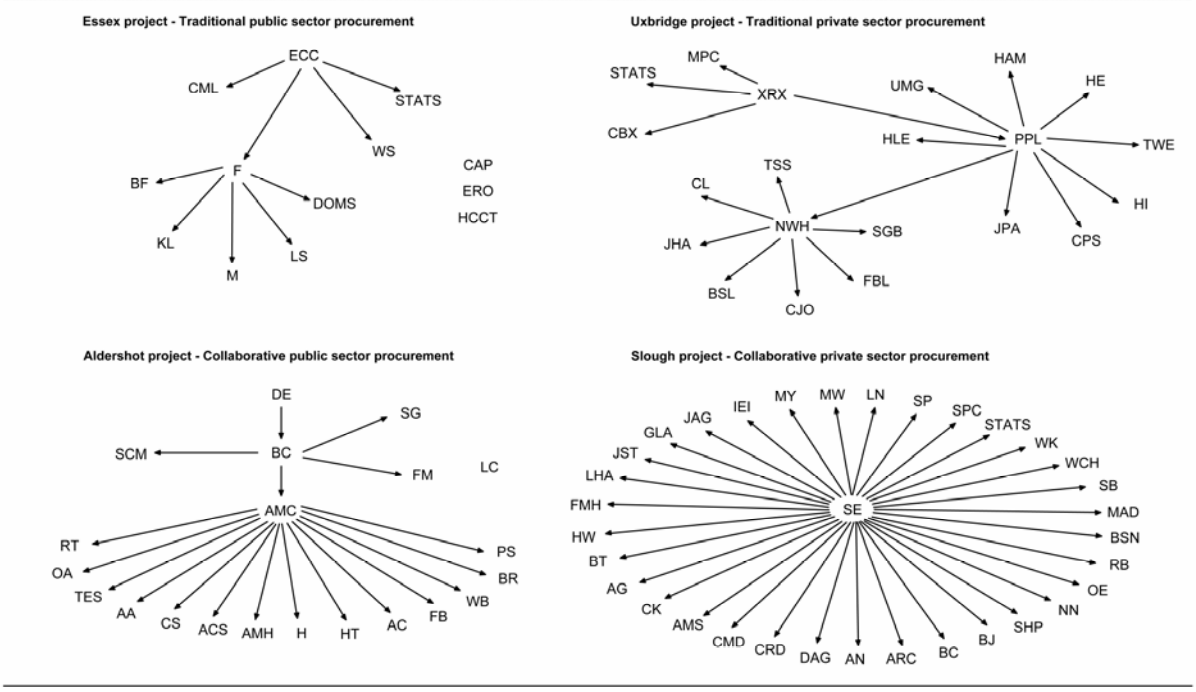
When the public sector wants to employ a supply chain management approach to procurement it may find that it needs to use a supply chain managing 'agent'. This was the case with the Aldershot project. The client (LC) is represented by DE, using a project manager BC and finally a prime contractor AMC in order to manage the supply chain. This is a long chain of command (in network terms, a long path length) serving a client with little knowledge, experience or inclination to engage in construction projects. The private sector developer on the Slough project acts as *principal contractor, and therefore Tier 1* of the supply chain, using in-house resources to do much of what might be regarded as the Tier 1 function. The developer (SE) locates itself from a contractual and communication network point of view at the centre of a 'hub and spoke' network configuration.

The important things to note about the Slough network compared to all others are:

- There is no hierarchy in this network
- There are the shortest possible path lengths between the developer and Tier 2 subcontractors and suppliers
- The developer has a very high level of prominence in the network being connected to all other actors in the network

It is argued that these unusually short path lengths between client (developer) and Tier 2 facilitated very high levels of knowledge transfer between client and Tier 2. The client learned a great deal about issues associated with site activities. Perhaps uniquely in construction, site operatives had the opportunity to understand how to add value to the client's business.

Fig.1 - Contract Networks



5.2 What did the client achieve on the Slough project?

In summary, the following benefits were derived by the client as a result of the short path lengths in both contractual and communication networks:

- Construction costs consistently at 15-20% below market costs and independently validated by independent consultant QSs

- Through better knowledge and the ability to internalise risk and manage it (rather than externalise and export to the supply chain), construction costs were controlled to within +1%

- More accurate risk identification and quantification resulted in the client employing its own cladding designer (poached from a Tier 2 sub-contractor) in order to complete cladding design early and resolve interface details with other building elements

- Close collaboration with site operatives enabled the establishment and training of a generic site assembly team which operated over a number of packages - the same team would erect the steel frame, fix glazing and install vertical cladding. The ambition was to move towards the majority of site labour being provide by one multi-skilled team

- Closeness to, and direct contractual relationships with, mechanical services designers lead to the reconfiguration of roles and responsibilities in relation to mechanical services. The developer entered into a design and install relationship with an organisation that might be regarded as a consultant. The role of IEI was to design but provide a lump sum price for the installation of all mechanical services, with the intention that IEI managed the mechanical services supply chain on behalf of the client. IEI as an actor reflected the client organisation SE.

- Close collaboration by the client with cladding fixers, the UK Health and Safety Executive and the manufacturers and hirers of hydraulic equipment enabled the removal of all scaffolding to the external elevations of commercial buildings under construction. As the client needed to let the building whilst under construction this provided a more satisfactory presentation of the property under construction to prospective tenants.

6. Conclusions

The research used SNA to analyse sets of transaction associated with four projects. These transaction sets reflected the functions of the project coalition. The contractual relationships reflecting the governance of these transaction sets reveal the importance of short path lengths in achieving knowledge transfer to both client and Tier 2 and below; these short path lengths coupled with complete centrality of the client enabled a range of innovations and initiatives with the potential to deliver projects that explore customer delight and exceeding minimum measurable standards of cost, time and quality.

Space has permitted only a brief overview of the case studies undertaken. Considerably more information is available in relation to theoretical framework, SNA as a method and the details of the case studies in Pryke (2012). Recession in the UK has led many UK organisations to abandon supply chain management (SCM). It is, however, argued that the rational response to recession and falling tender levels is the pursuit of improved cost reduction and improved client value and working methods facilitated through short path lengths between clients and their Tier 2 - the gateway to their supply chain.

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International coordination of Facilities Management in multinational corporations

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Abstract

There has in recent years been a general trend towards increasing cross border coordination of Facilities Management (FM) and Corporate Real Estate Management (CREM) in international operating organisations. The largest international FM providers and real estate companies have also increasingly focused on supporting their corporate clients on regional and global level. However, the reasons and consequences of this important development have only to a very limited extent been in focus of academic research.

The purpose of this paper it to investigate the different ways the international coordination of FM is organised in multinational companies, the drivers of cross border coordination, and the consequences for the way facilities and construction activities are managed and for the relationships between the clients and users. The research is based on literature review, organisational theory in relation to globalisation and coordination, and empirically on a number of cases of Danish based multinational companies.

One of the main conclusions is that the type of multinational corporations has a major influence on the degree and the way of international coordination of FM, but the degree of top management focus on FM is also of major importance. Increased transparency, cost savings and standardisation are among the most important drivers for the increased international coordination. In an international FM organisation the communication channels to the central and local management of the core business needs to be designed carefully and it is important with a combination of a central client function with local client representatives to ensure the necessary consideration for and adaptation to the local needs of the end users.

Keywords: Facilities Management, Real Estate, Multinational companies, International coordination, Client organisation

1. Introduction

The international diffusion of Facilities Management (or Facility Management - FM) as a new management practice has very much happened via multinational companies. The diffusion of FM in multinational companies has over the years been followed by increasing cross border coordination of the FM activities and a general trend towards centralisation of decision making. There is also a trend that multinational companies increasingly prefer to outsource FM services to multinational providers.

The trend towards increasing cross border coordination of FM has so far only to a very limited extent been in focus of academic research. The purpose of this paper it to investigate the different ways the international coordination of FM is organised in multinational companies, the drivers of cross border coordination, and the consequences for the way facilities and construction activities are managed and for the relationships between the clients and users. The research is based on a literature review of related studies, organisational theory in relation to globalisation and coordination, and empirically on a number of cases of Danish based multinational companies.

2. Literature review

The historical development of real estate management from a corporate perspective has been studied in a Dutch PhD project by Krumm (2001). The research is based on case studies of 8 Dutch-based multinational companies including Philips, Shell and Unilever. Krumm writes that the founders/owners of corporations for a long time had a strong direct involvement in real estate activities, but with international expansion of corporations the separate discipline of Corporate Real Estate Management (CREM) was established leading to large centralised real estate departments. The best known arguments for establishing real estate departments were (Krumm, 2001, p. 278):

- Control construction activities, both technically and financially
- Standardise building design
- Guarantee the availability of skilled employees
- Create and maintain a corporate image though the architecture of their buildings

The situation changed from the beginning of the 1980’s due to increasing globalisation of the economy with a trend towards most corporations having decentralised real estate responsibilities and activities to operating companies with only a limited number of staff involved with corporate, regional and national management of real estate resources and capabilities. This was triggered by an increased international competition and a change in corporate organisations from along geographical lines towards product oriented lines. This caused a focus on rationalising real estate portfolios and outsourcing non-core activities.

The article by Krumm from 2001 finishes with some expectations about the future of corporate real estate. He writes that after the radical shift from the traditional focus on control towards autonomy, some corporations are now in the process of reinstating corporate-wide coordination of resources and capabilities, while others are taking the next step towards corporate integration and alignment of various supporting disciplines. Increasingly, corporations are reviving in-house departments and establishing a real estate strategy. The objective of CREM departments is no longer to dictate a corporate mandate but to provide operating companies with added value over their competitors. Merely outsourcing activities on the basis of achieving operational efficiency is no longer regarded as an acceptable strategy. A tendency towards a global or regional coordination, regrouping of geographical organisations and of real estate, will increase in the future. Functional clustering of infrastructure-related activities like human resource, information technology and corporate real estate in a special division can currently be seen in several corporations.

Krumm (2001) does not refer to any general organisational theories, but organisational terms like centralisation/decentralisation, coordination and alignment are very central in his analysis. He concludes it is about finding the right balance for each corporation between optimising the performance of the real estate portfolio and the value of real estate to core business processes – between economies of scale and operational responsiveness.

Another Dutch study based on a master thesis focuses specifically on managing FM organisations across borders in multinational corporations (Van der Kluit, 2005). The study is based on telephone interviews with 80 FM directors from the Netherlands in multinational corporations followed by a number of case studies. In line with Krumm (2001) the study focuses on the balance between responsiveness and international coordination and it presents the international triangle of tension shown in Figure 1.

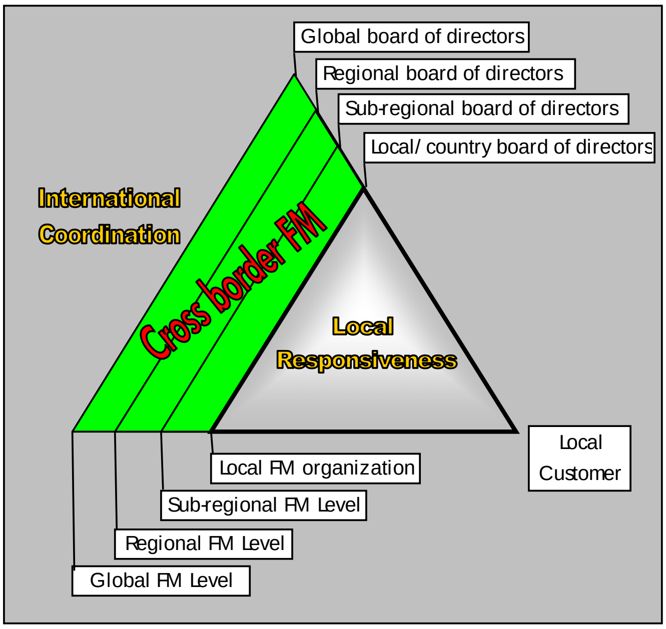

Figure 1: International Triangle of Tensions (Van der Kluit, 2005)

Van der Kluit (2005) also defines the following five types of FM organisations in multinational corporations with an increasing degree of international coordination:

1. The local, autonomous, FM organisation;

2. Awareness of counterparts in other countries: communication;
3. Awareness of counterparts in other countries: purchasing;
4. Work together in cross border project teams;
5. Cross border management: Multinationals' FM organisation.

The study concludes that supporting the growth of the primary organisation was most important in the past, but at present and in the future the most important parameters are cost reduction, standardisation and flexibility. The balance between local responsiveness and international coordination experience a shift from local oriented to more centralised and global FM organisations. The study includes a theoretical elaboration of the concept of coordination and coordination mechanisms. A general organisational distinction is mentioned between vertical coordination between a corporate centre and the operating units and horizontal coordination across operating units. Furthermore, three more specific coordination mechanisms based on the research by Bartlett and Ghoshal (1987 and 1998) on managing across borders are defined: centralisation, formalisation and socialisation.

Recent research by Kok (2012) presents a theoretical study of the alignment between in-house FM and the core business. He also uses coordination as a central term but with a different interpretation. With reference to March and Simon (1958) and later organisational theorists he claims that there are two basic ways in which organisations can be coordinated: feedback, also called mutual adjustments, and plan, also called programming. Kok concludes that FM alignment concerns the coordination between FM and demand, which reflects in building and maintaining a multi level collaborative relationship.

A different concept of coordination is based on theory of transaction economics developed by Williamson (1981). The term "form of coordination" is used for a method of managing or governing organisational relationships. The two basic governance structures are market and hierarchy. The concept of form of coordination has been further developed by Grandori (1997), who distinguishes between seven forms or mechanisms of coordination: price, voting, authority relationships, agent relationships, teams, negotiation and norms/customs. These are archetypes, and in reality hybrids will often exist. Grandori emphasises that all forms of coordination can be used both internally in a company (intra-organisational) and in cross company collaboration (inter-organisational). The seven forms of coordination have in Table 1 been organised horizontally according to the degree of centralisation and vertically according to the number of decision making parties. The seven forms of coordination from Grandori have been supplemented by the following two forms: partnership and coalition.

Table 1: Forms of coordination related to centralisation and decision making (Jensen, 2011)

Degree of centralisation *Decision making*	*Centralised*	*Semi-centralised*	*De-centralised*
One-sided	*Authority relationship*	*Agent relationship*	*Norms/customs*
Two-sided	*Partnership*	*Negotiation*	*Price*
Multi-sided	*Coalition*	*Voting*	*Team*

The analysis in Jensen (2011) of the organisation of FM in relation to core business based on the forms of coordination in table 1 concludes, that at strategic level a coalition involving all main stakeholders in a corporation with joint decision making based on an overall business orientation is likely to be most appropriate. Negotiation between FM and the management of each business unit each with a customer orientation is most appropriate on tactical level, and price is seen as the most appropriate form of coordination at the operational level with a service orientation towards the end user.

3. Methodology

The paper is based on three main case studies from Danish based multinational companies. Case 1 concerns a company which during 2011has undertaken an investigation called FM Deep Dive about possible change from having a FM unit at the headquarters with responsibility only for the sites in Denmark towards some degree of international coordination of FM. The author was involved in the project as an external expert. The investigation included an interview survey covering facilities managers in 10 other Danish based companies as part of a qualitative benchmark study. The companies were chosen because they are multinational from different branches of industry. The interviews were carried out by the internal facilities managers and a process consultant from a consulting company. The author was involved in developing interview questions, analysing the results and discussing them at a workshop in the case company, where all the other companies were invited.

Case 2 and 3 concerned two of the 10 other Danish based multinational companies included in the interview survey from case 1. The author had beforehand together with other researchers made case studies about FM at both companies, and the two companies were included in the interview survey as representing two very different examples of international coordination of FM.

Case 1, 2 and 3 are presented further in the following section. The remaining 8 companies are all production companies with international activities to various degrees and only very overall data about these companies are included in this paper as part of the description of case 1.

4. Empirical findings

4.1 Case 1

Case 1 is the biotechnical company Novozymes A/S, which is quite young as a separate company. It was founded in year 2000, but it is part of the Novo Group with a long history. The company is expanding fast on the global market. It has over 700 products used in 130 countries, possesses 6.500 patents and has approx. 6.000 employees worldwide. The global organisation is divided in five regions with regional offices in Denmark (headquarters), Brazil, China, India and US.

The company has only had its own FM unit at the headquarters since 2007. Before then they bought FM support from the former mother company. The FM unit has gradually increased their area of responsibility in Denmark with the most recent being building client function and risk management in 2011. The FM unit is small with an administrative staff of approx. 6 in 2011. All facility services are outsourced – for most parts as an integrated FM (I-FM) contract to an external provider. FM is placed as part of Stakeholder Relations in Region Europe three levels below the board of directors.

The governance structure for FM includes a Space Committee in relation to decisions on FM and space utilisation in Denmark. The committee is chaired by the head of Region Europe and includes besides the facilities manager also a vice president from Finance, the global production director, the vice president for R&D and the secretary for the board of directors. A proposal from the FM unit on space standards in Denmark has been approved by the board of directors. Decisions about Corporate Visual Identity are taken by the board based on proposals from FM and the branding department. The strategic planning in the company includes 10 years prognoses for number of staff with annual updates. The real estate strategy includes that they in general own all facilities except for sales offices outside Denmark, which are rented.

Today there is no coordination with FM units on sites outside Denmark. The regional site president or general manager decides on the level of FM services and has the budgetary responsibility. Decisions on establishing new sites outside Denmark are initiated by the global production director or the head of R&D and decided by the board of directors. The global production director or the head of R&D are also responsible for the building projects and building operation.

One of the main results of the interview survey was a mapping of each company according to their geographical focus measured as degree of FM globalisation and the degree of management focus on FM. The results are shown in Figure 2. The three main cases are numbered 1, 2 and 3 and the other companies are numbered from 4 to 11.

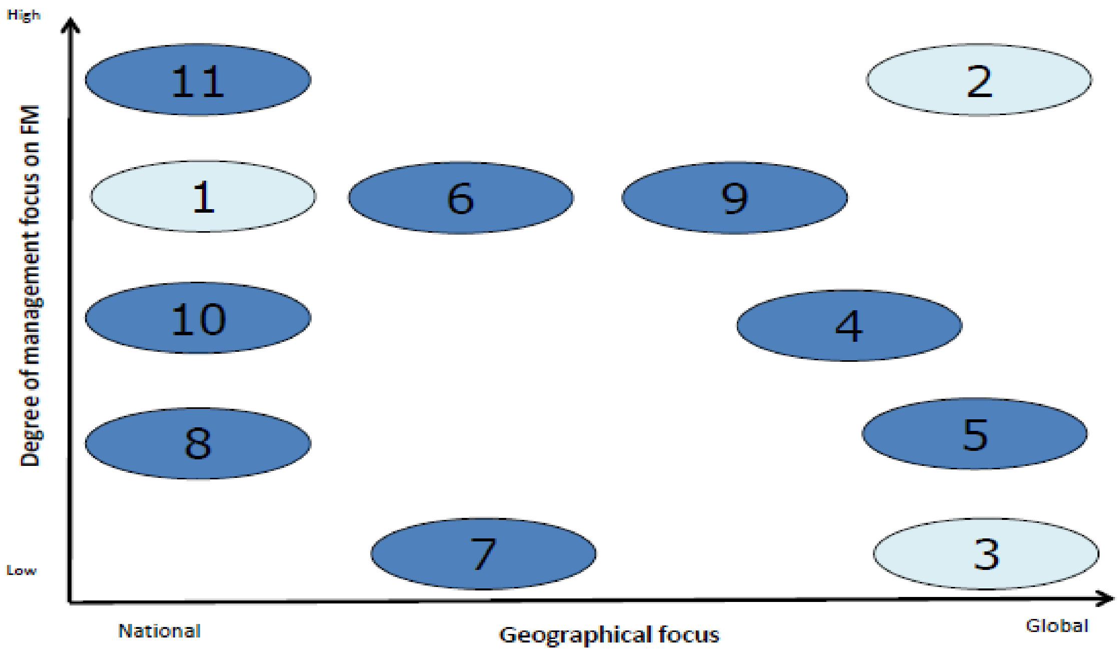

Figure 2: Globalisation versus management focus of FM (Based on Andersen, 2011)

The figure shows that case 1 is one out of four companies with a pure national focus and out of these case 1 has the next highest management focus on FM. Case 2 and 3 represents the extremes in relation to global focus combined with high degree of management focus for case 1 and low degree of management focus for case 3. The remaining companies are placed in different positions within the extremes of case 1, 2 and 3.

Based on the recommendations from the FM Deep Dive project the board of directors have decided to initiate a project to be undertaken in 2012-13 about the possible establishment of a global FM organisation. The goal is to develop and implement a comprehensive and more strategic FM approach with better transparency of FM, standards and plans for how to best utilize and develop their sites and buildings. Cost savings are also probable, but this is not the main driver for the project. Such a global FM organisation is initially suggested to include a global FM director supplemented by a central FM competence centre and regions for Europe, Americas and Asia.

4.2 Case 2

Case 2 is a well consolidated family owned company group producing toy products for the global market. The headquarters is placed in Denmark, but they have production facilities and sales offices around the world. The group has approx. 9.000 employees. The FM unit in the company has global responsibility and is a part of Corporate Service Centre (CSC). This is an integrated business unit encompassing besides FM support services such as information technology (IT), human resources (HR), indirect (not production related) procurement and reception.

The management of CSC participates in an annual meeting with the corporate top management – the leadership team – to evaluate performance and discuss development plans. In order to align strategic management decisions between top management and FM on a continuous basis, they have established a Facility Committee with the main focus on the three aspects: projects, capacity, and competency. The meetings are held every 6 weeks. An example of the procedure is the situation, when the company wants to expand with a new production line. The Facility Committee will ask for collaboration from head of Global Supply Chain, CFO and FM to create dialogue on the strategic level across the corporate organisation. The FM unit will investigate a number of alternative locations and these will be evaluated by the main stakeholders and decisions will be made jointly by the members of the Facility Committee. The real estate strategy includes that the company owns all production facilities, while offices are rented. However, the offices at the headquarters are rented by an investments company owned by the family, who also owns the production company.

In CSC, FM has the closest connections to the sites around the world and represents all units in CSC in relation to the sites outside Denmark. Building projects are managed by Global Project Management from the FM unit, but they engage local architects, engineers and contractors. Most of FM services are produced in-house, both in Denmark and internationally. The FM unit is represented at 6 different sites around the world and had a staff of 132 in 2010 with 75 at the head office, including cleaning staff. CSC's service levels are negotiated and decided bilaterally with the management of each business unit as customers. The FM unit has the budget for all FM services. CSC measures their performance based on satisfaction surveys by regular intervals among internal clients, customers, end users and FM staff.

The FM unit has a strong focus on value add. They divide value add into financial and non-financial value - financial value is measured in terms of cost reductions and non-financial value are measured in terms of volume, quality and flexibility. It can also be shown as CO_2 emission reduction, environmental portfolio and green account. An added value report is a supplementary part of the financial report, which is delivered annually to their internal client and customers. The objective of FM is to deliver minimum 5% value add every year. This is measured by the so-called value add equation: Value add = Volume * Quality * Flexibility / Cost (Møllebjerg, 2010). Only value add based on initiatives from the FM unit and recognised by the customers can be included in the measurements. The value add equation is both seen as a dialogue tool in stakeholder management and an internal management tool in the FM unit to make the staff focus on their customers and be aware why the staff is there.

4.3 Case 3

Case 3 is a Fortune 500 diversified corporation with activities in different industries and a strong focus on service. The corporation has subsidiaries in excess of 100 countries around the world. The corporation has a few years back carried out a global outsourcing on an I-FM contract. The contract is managed by the real estate unit, which is part of corporate procurement. The I-FM contract mostly covers operational facilities services. Activities related to property management and workspace management is also the responsibility of the real estate unit, but it is not part of the I-FM contract. Even though the I-FM contract by principle is global and the provider is one of the most globalised FM companies, it has not been possible to include all sites, where the corporation has activities, because the service provider is not present in all countries. Initially the service provider had a direct presence at 40 out of 54 clusters, where the corporation had activities, but the aim is to gradually include more clusters in the collaboration.

The real estate unit see the collaboration with the service provider as a strategic partnership between the client and the provider and it is a mandatory group framework agreement. There is a gain sharing agreement between the parties and no penalty system. The contract is based on a guaranteed maximum price with expected cost reduction of 21% over the first three year of transition of a site. There is one-point of contact both centrally and between the service providers' area or site manager and a representative from the business unit or site in question. Service Level Agreements (SLA's) are not determined globally but decided locally. The service provision is monitored globally by Key Performance Indicators (KPI's) once per year. The corporation aim to achieve cost reductions, process improvements and scalability of services. However, the most important goal for the client is security and stability of service delivery.

The executive board has delegated the responsibility for FM to the real estate department and shows no interest in it. Real estate only represents 1-2% of the corporate turnover. The general policy is to rent office buildings. The real estate unit has a central IT-system (portfolio intelligence) to monitor rent costs and space usage per head in all locations. However, the different business unit has a very high degree of autonomy. Each line of business has their individual visual identity.

5. Analysis

The three cases on Danish multinational companies represent three extremes in relation to combination of degree of globalisation of FM and degree of management focus on FM as illustrated in Figure 2. Case 1 has a small FM unit at the head office, which is only concerned with activities in Denmark with a high degree of outsourcing and there are no dedicated FM functions outside Denmark, but the management focus on FM is high. Case 2 also has a central FM unit at the head office, which has global responsibility and is represented at sites around the world with a low degree of outsourcing, and the management focus on FM is high. Case 3 has a small real estate unit at the head office, which has responsibility for a global I-FM contract, but the management focus on FM is very low.

Case 2 is a clear example of an FM unit which follows the principles from Jensen (2011) as explained in the literature review. The Facility Committee is a coalition at strategic level with a business orientation and a global focus. Service levels are negotiated and decided bilaterally at the tactical level with the management from each business unit as customers and the service are delivered with a service orientation to the end users on operational level. This means that the forms of coordination according to table 1 are coalition on strategic level, negotiation on tactical level and price on operational level.

Case 1 shows similar characteristics but - at least at the moment - only in relation to FM in Denmark. The Space Committee is similarly to the Facility Committee in case 1 a coalition at strategic level with a business orientation, but only with a national focus. The service levels are not negotiated with each business unit but standardised and included in outsourcing contracts in Denmark.

Case 3 is quite different. The relation between top management and the real estate unit at strategic level is clearly one-sided and can be characterised as an authority and/or agent relationship according to the forms of coordination in table 1. The relation to each business unit at tactical level is two-sided, where the real estate unit assists in negotiating and monitoring the specific agreement on service levels for sites around the world between the business unit and the I-FM provider, and can therefore be seen as a partnership. In relation to the operational level the real estate unit is only involved in monitoring and evaluating the service delivery. The relation between the real estate unit and the I-FM provider is also a partnership at central level, while the relation between the providers area or site managers and representatives from the business units or sites probably best can be characterised as a combination of coordination by negotiation and price.

From the above is seems that the theory and typology of forms of coordination based on transaction cost economics provides an appropriate framework for characterising the relationships between FM and core business in the different cases. This is a fairly general analysis and static characterisation.

Some of the other interpretations of coordination presented in the literature review might be appropriate in a more detailed analysis, but that is beyond the scope of this paper.

The differences between the three cases are likely to be related to the different types of corporations they each represent. There has been made a number of proposals for typologies of multinational corporations. Harzing (2000) compares 19 different such typologies. One of the most influential is by Bartlett and Ghoshal (1998), which has been tested by other researchers, including by Harzing (2000). The typology includes the following for types: Multidomestic, International, Global and Transnational. These four types illustrate, which strategic outlook multinational corporations have towards managing their subsidiaries, and how they balance the potential needs of global integration and global differentiation as shown in Figure 3. Integration can be related to international coordination and differentiation can be related to local responsiveness.

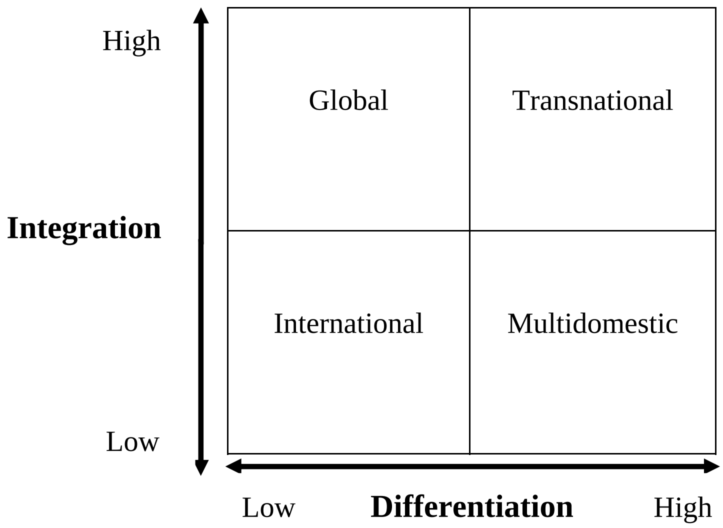

Figure 3: Typology of multinational corporations (Bartlett and Ghoshal, 1998)

In relation to this typology case 1 and 2 can be characterised as International with low differentiation and low integration, while case 3 can be characterised as Transnational with high differentiation and high integration.

The International strategy (case 1 and 2) is based on home country expertise. The majority of the value chain will be maintained at the headquarters. The control of technologies used for e.g. production and general management systems will be structured and developed at home. The development of knowledge and innovation will stream from the home organization to the subsidiaries. The differences between case 1 and 2 is mainly based on case 1 being very young as a separate company and the need to develop a global and international coordinated is beginning to be understood.

The Transnational strategy (case 3) tries to maximize both responsiveness and integration, where knowledge and innovation is sought developed and dispersed within the entire network. The corporation is regarded as a network, and each subsidiary is given responsibility compared to its capabilities and strategic mission. The corporation is controlled by the movement of people within the corporation that may facilitate the mutual development and dispersion of innovation and knowledge.

6. Conclusion and recommendations

A main conclusion is that the type of multinational corporations has a major influence on the degree and the way of international coordination of FM, but the degree of top management focus on FM is also of major importance. The concept of forms of coordination based on transaction cost economics seems to be an appropriate framework to characterise and differentiate the relationships between FM and core business in the 3 main cases. Case 1 and 2 is characterised by following the International strategy (see figure 3) and building projects are in both companies mainly decided and managed from the head office. Case 3 is characterised by following the Transnational strategy (see figure 3) and buildings are mostly rented and decided on by each subsidiary.

Increased transparency, cost savings and standardisation are among the most important drivers for the increased international coordination. Implementation of further international coordination often occurs gradually starting with centralisation of decisions of new construction projects with standardised procedures and a common corporate visual identity is often an important element.

The literature review revealed that the term coordination is used with different meanings and interpretations in various studies. There seems to be a need to clarify how these different meanings relate to each other and whether it is possible to create a coherent understanding of the concept of coordination in an organisational context.

From the case studies and the FM Deep Dive project in relation to case 1 some general recommendations and considerations in relation to managing a process of increased globalisation of FM in a multinational corporation can be identified.

The FM-organisation should be designed in accordance with the corporate business systems and their development. It is important to start to create overview and transparency about financial data. Make sure the top management fully support the new strategy. Start by managing the establishment of new sites and not by confronting existing business around the world. Focus on the regions where you expect to expand. Develop different strategies in relation to emerging and developed markets.

In an international FM organisation the communication channels to the central and local management of the core business needs to be designed carefully and it is important with a combination of a central client function with local client representatives to ensure the necessary consideration for and adaptation to the local needs of the end users.

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Manipulating data from defects liability management system and their impact on hospital project variables

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Abstract

Defects detected during the Defects Liability Period (DLP) of a construction project suggest that the project management team have not managed the project effectively somewhere during the project implementation stage. Clients, especially those with little project management experience are usually at a lost in trying to configure how this should be dealt with. Since resolving issue relating to construction defects can be vexing and time consuming, the Malaysian government has introduced a Defects Liability Management (DLM) system to manage defects in their projects. Through this system, a third party consultant or a Service Provider is appointed to record and manage the defects identified during the DLP. Realising the opportunity that can be learnt from these pilot projects in providing insights to improve the implementation of future projects, a research was mooted. The focus of the research was to investigate the defects data management process with the view of establishing how best defects can be tracked to the implementation process. The case study of seven design and build (DB) hospital projects were chosen for the research and data were abstracted from two project documents. The data were than analysed using various statistical tools.

The findings underline the significance of implementing a comprehensive DLM system to capture, manage and documenting all defect rectification works undertaken by the DB contractor. It also suggests that by manipulating the data variables obtained from this system, many insights can be attained to understand the kind of association that exists between the different elements of the defects and the project stage.

Keywords: Defects, defects liability period, Defects Liability Management system, design and build, hospital

1. Introduction

Defects can be associated to construction failures emanating from shortcomings during the project implementation process. In construction, parties managing construction projects are frequently aware of the signals that lead to defects or diagnose the causes of the defect to take preventive action (Jorgensen, 2009) and (Isa et al., 2010). This phenomenon is common in the DB hospital projects in Malaysia. It was often argued that most defects in these projects are not properly recorded, which consequently led client ending up rectifying the defects themselves and at their own cost. To assist address this problem, a research was mooted to investigate the extent to which defects data collected during the DLP can be expanded to provide insights to their root cause for the purpose of learning from the project. Two objectives were established to operationalise the research: (1) to investigate the DLM system as practiced in Malaysia (2) to identify to what extent the DLM process can be used to provide insights to the problems along the project implementation and promote lesson learn for future projects.

2. Theoretical framework

2.1 Defects generally

Construction defects are commonly defined as a failure or shortcoming in the building's function, performance, statutory or user requirements, and this may occur in its structure, fabric, services or other facilities (Pheng and Wee, 2001; Mills et al., 2009; Olanrewaju et al, 2010). Rhodes and Smallwood (2002) classified defects into two namely patent and latent defects. Patent defects can be clearly recognized during project joint inspection and latent defects will usually appear over time after the building is occupied. Defects can occur not only in building operational phase but also before and during the construction stage (Mills et al., 2009; Olanrewaju et al., 2010; Jorgen et al., 2006). It manifest within a few common interrelated factors such as cause, erroneous action and defect consequence (Josephson & Hammarlund, 1999). Failure to address them would most likely contribute to additional rectification cost, hamper the smooth operation of the building and reduce its service life. In extreme cases, defects may even lead to accidents and disasters.

A number of studies have been undertaken to understand the causal relationships that lead to defects (Pheng and Wee, 2001; Grobler and Pretorius, 2002; Mills et al., 2009). Common in the findings is the conception that most of the defects are as a consequence of 'weaknesses' in the project implementation process. Isa et al., (2010) revealed that there are many causes of defects and poor design decisions are identified as the most significant contributor towards defects. Therefore, the designers play an important role to eliminate defects. They have the duty to ensure that all the client requirements are well captured, translated and communicated to the other project team members throughout the project implementation process. Notwithstanding this, proper documentation and early involvement of the client or end user are also important factors to be considered.

2.2 Defects and its implication in the Malaysian construction projects

Construction defect is a common phenomenon in Malaysia, particularly involving DB projects. This gives great impact to the industry and the government had to allocate a sum of money to rectify those defects. Consequently, they are not getting value for money from their investment. As a result, the government is now considering in implementing punitive measures against those who flout the rules and regulations (Nordin, 2010). Following this, the Ministry of Education went to the extent of suspending the use of DB procurement system in their 9th Malaysia Plan projects and the Ministry of Health warned that they will not accept hospitals with such problem in future.

Nevertheless, defects also convey positive influence to the industry. The Public Works Department (PWD), for instance had formed the Building Facility Maintenance Division to monitor and audit the performance of public projects. Furthermore, most of the facilities management consultants in Malaysia nowadays, had provided value added services to the government by providing defects liability management services to identify and manage defects works on site. On the conviction that the additional cost of engaging the defects liability management consultant can be offset with all the defects resolved when the building is in use, DLM system was introduced. Through this system, the Service Provider (SP) is appointed by the government to manage defects during the DLP. A key task of the SP is to capture and record all the defects, propose their rectification methods and closely monitor the works undertaken by the DB contractor complies with the contract. All the data recorded by the SP will be utilise by the project team as lesson learned in undertaking future hospital projects.

2.3 Rationale for re-learning the defects

Isa et al, (2010) revealed that architectural defects are the common defects usually occurred in the public hospital projects, even when it is being constructed by the same contractor. This raises the question of: what are these defects? Why are they recurring? And, what are their root causes? These are fundamental questions that need to be answered so that similar mistakes will not be repeated in future. Therefore, by recording and classifying those defects into systematic categories, the types and causes of each defect can be identified. In addition, the most recurring defects can also be traced. This significant information can be used to provide lessons learn to assist the industry in identifying what went wrong and how to better manage future projects. This is in line with Le and Bronn (2007) and Kululanga and Kuotcha (2008) stating that knowledge and experience are two integral intellectual assets for value creation process. By reapplying both to avoid similar mistakes, the project teams can realise cost efficiency improvements and increased design and performance quality.

3. Research methodology

Seven DB public hospital projects in Malaysia are chosen as the case study. This was in the justification that there were very few available education DB project at the time of research but there were available data from DB hospital projects that can serve as excellent case studies. Furthermore, hospital projects are usually more complex and there is much that can be learnt from hospital projects which can be applied in other building projects. A qualitative approach using document analysis was adopted and further explained as follows;

(i) the Procedures Guideline Manual - to investigate the DLM system as implemented by the SP

(ii) the project audit documents - to identify to what extent the system can be used to provide insights to the problems along the project implementation and promote lesson learn for future projects

Following this, data analysed from the project audit documents were sorted, sieved, grouped and transferred into the SPSS software by using frequency analysis.

4. Findings

In line with the research objectives, the findings were divided into the following themes for further discussion and presented as follows:

4.1 The DLM system

The SP through several discussions and a workshop conducted with PWD, have designed PGM which defined all necessary processes and procedures involved in the DLM system to ensure that their service delivery is full compliance to PWD's requirement. This system is shown diagrammatically in Figure 1. Generally, the DLM system consists of two main processes namely Defects Liability Management Process (DLMP) and Equipment Warranty Management Process (EWMP). These processes are mainly for building works and mechanical, electrical and biomedical equipment works, irrespectively. Upon obtaining the DB contractor's defects list after the issuance of Certificate of Practical Completion (CPC), the SP will categorise the defects into the various disciplines. Then, they will perform physical verification of the defects on site and subsequently track each defect until it has been resolved by the DB contractor. If the rectification works complies with the contract, the PD representative will signed and close the work order.

Meanwhile, EWMP covers the Planned Preventive Maintenance (PPM) works. The DB contractor will submit the entire schedule to keep equipment's and machines up and running well. These schedules will be approved by the PD representative and the works will be monitored closely by the SP. A non-compliance report will be provided to the PD if the contractors fail to perform the required PPM. If there is any dispute occurs during the DLMP and EWMP, it will be resolve either through negotiation process or through the Dispute Resolution Committee.

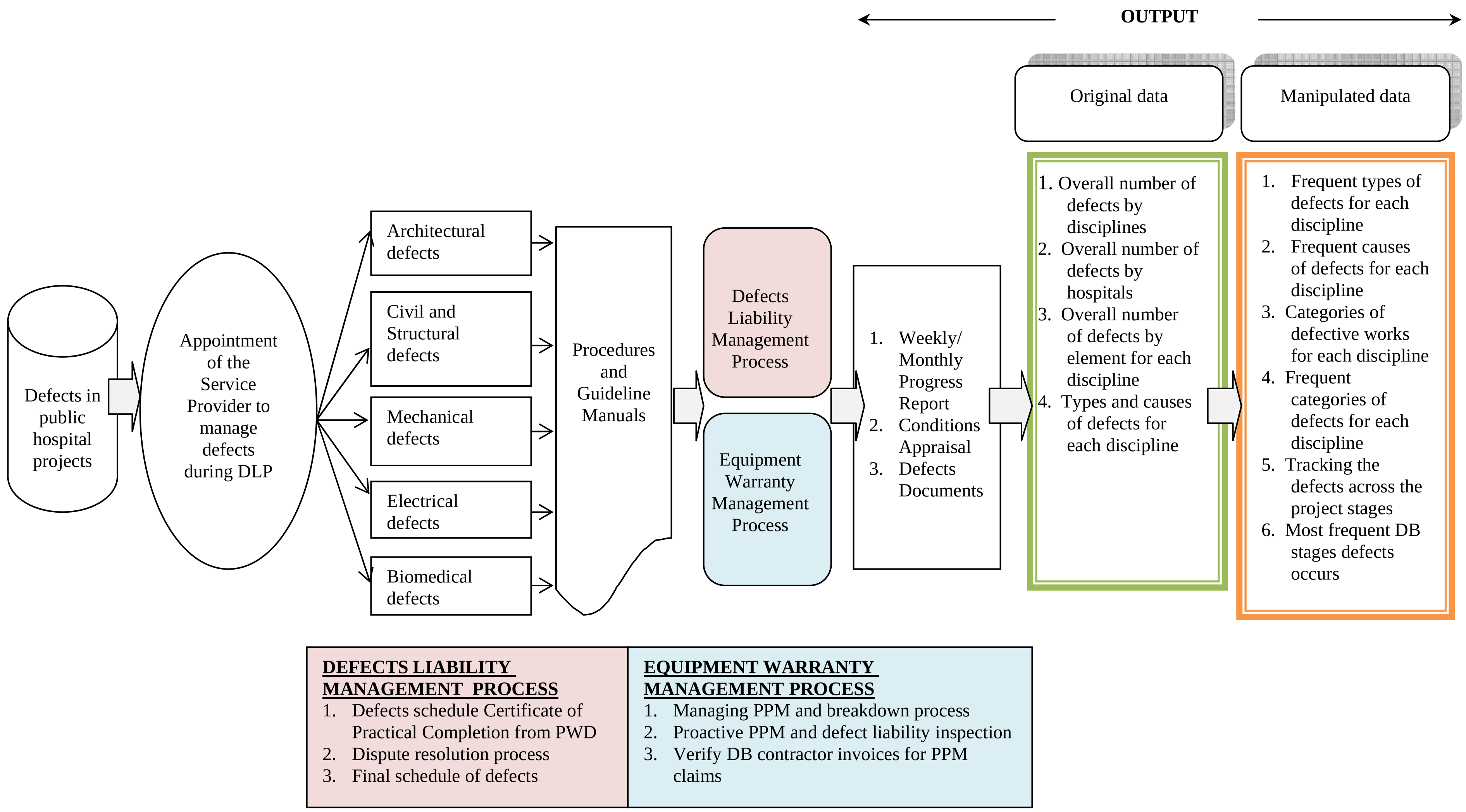

Figure 1: The Defects Liability Management System

The SP will compile all outstanding and new defects lists (if any) from the DLMP and EWMP works within 28 days from the expiration of the DLP and inform the DB Contractor. The DB Contractor is to rectify the defects within 3 months period before the Certificate of Making Good Defects (CMGD) is being released to the contractor. The SP will then document the defects data (Refer green box shown in Figure 1) into a Condition Appraisal Report for further endorsement from the PWD. Despite of the original data presented in the report, it is also believed that those data can be manipulated further to provide more insights to the project team as a lesson learn for betterment in managing future projects.

4.2 The defects report

4.2.1 Number of defects by element according to work discipline

Table 1 show that Hospital A is the most defective hospital, follows by Hospital E, B, D, F, C and G. Meanwhile, architectural (47%) is the most defective works, follows by electrical (21%), mechanical (20%), civil (7%) and bio-medical (5%).

Table 1: Overall number and rank of defects by element/discipline for each hospital

Element/Discipline	Hospital							**Total**	**Rank**
	A	B	C	D	E	F	G		
A) Architectural	**5483**	**2301**	**477**	**1302**	**2164**	**1343**	**448**	**13518**	**1**
1. Building Signage	543	27	0	0	15	8	0	593	7
2. Built-in & Loose Furniture	824	131	26	85	158	303	12	1539	4
3. Ceilings	1130	196	96	287	371	151	133	2364	3
4. Doors & Fittings	1470	670	66	488	357	298	39	3388	1
5. Fittings, Fixtures & Curtain Tracks	131	117	1	22	59	32	0	362	8
6. Landscape	54	0	0	1	97	0	0	152	10
7. Others Architectural	187	446	18	70	438	20	42	1221	5
8. Roofs	52	0	23	38	33	7	48	201	9
9. Sanitary Fittings, Fixtures & Toilet Cubicles	273	486	28	45	36	27	0	895	6
10. Wall, Floor & Finishes	819	228	219	266	600	434	174	2740	2
B) Biomedical	**505**	**98**	**76**	**77**	**544**	**0**	**7**	**1307**	**5**
1. Bio-Medical Equipment Package	354	0	11	11	206	0	4	586	1
2. Electrical Package	88	53	5	3	37	0	0	186	3
3. Mechanical Package	26	0	0	0	85	0	0	111	5
4. Non-Bio Medical Equipment Package	37	0	0	0	216	0	0	253	2
5. Others Bio-Medical	0	45	60	63	0	0	3	171	4
C) Civil & Structural	**393**	**443**	**119**	**33**	**894**	**0**	**31**	**1913**	**4**
1. Blockage	60	181	0	0	66	0	0	307	3
2. Building Crack	2	0	0	0	0	0	0	2	9

Element/Discipline	Hospital							Total	Rank
	A	B	C	D	E	F	G		
C) Civil & Structural									
3. Drainage	7	0	57	13	0	0	5	82	6
4. Leakage	30	180	0	0	341	0	0	551	1
5. Others Civil	17	15	34	14	89	0	6	175	5
6. Pipe Installation	20	24	0	0	375	0	0	419	2
7. Road System	0	0	12	3	16	0	16	47	7
8. Soil Treatment Plant	15	0	10	2	7	0	0	34	8
9. Waterproofing	242	43	6	1	0	0	4	296	4
D) Electrical	**2262**	**1510**	**182**	**651**	**1172**	**230**	**66**	**6073**	**2**
1. Electrical Supply System & Fittings	374	296	9	242	78	76	8	1083	3
2. Lighting System & Garden Lamp	1572	49	84	145	513	154	23	2540	1
3. Low Voltage Equipment System	204	204	20	26	329	0	5	788	4
4. Others Electrical	112	961	69	238	252	0	30	1662	2
E) Mechanical	**1208**	**1099**	**169**	**667**	**1865**	**606**	**52**	**5666**	**3**
1. Air Conditioning, Ventilation & Exhaust System	736	0	74	28	1220	215	21	2294	1
2. Fire Fighting Equipment System	143	32	10	35	331	38	0	589	4
3. Medical Gas Equipment System	114	15	4	23	158	0	3	317	5
4. Others Mechanical	209	1039	66	171	156	97	16	1754	2
5. Pipe & Sanitary Appliances	6	13	15	410	0	256	12	712	3
Total	**9851**	**5451**	**1023**	**2730**	**6639**	**2179**	**604**	**28477**	
Rank	1	3	6	4	2	5	7		

Architectural works are ranked as the common defects in Hospital A, whilst, civil, mechanical and biomedical works are the highest defects occur in Hospital E. However, there are no biomedical and civil defects recorded in Hospital F. Apart from illustrating the numbers of overall defects, table above also highlights and ranks the most defective elements involved in each of the work discipline for every hospital.

4.2.2 Frequent types of defects for each work discipline

The original data were manipulated by analysing the frequency of the types of defects occurrence for each discipline. Although there are many types of defects occurred, only the frequent defects will be discussed and this is tabulated in Table 2.

Table 2: Frequent Types of Defects

Item	Discipline	Frequent Types of Defects
A)	Architectural works	Hair-line crack at ceiling, peeling off paint at ceiling and wall, ceiling water mark and fungus, door leaf damaged/decayed, ironmongery damaged
B)	Civil and structural works	Water trap at road, pipe leakage, soil treatment plant defects
C)	Mechanical works	Temperature problems, non-functional of AHU, condensation, non-operational of fan coil unit, blockages of sanitary pipe, cold water pipe and floor traps, defective of sanitary appliances, ambulance problems
D)	Electrical works	Lightings not working
E)	Biomedical works	Equipment damaged, Oxygen Regulator problems, X-ray machine problems, Patient monitor problems

It is observed that the most frequent defective element in architectural works is ceiling. Types of ceiling defects frequently occurred in most of the hospitals are hair line crack, ceiling water mark and fungus. Despite of its occurrence in ceiling, peeling off paint also occurred in wall finishes. Door leaf damaged/decayed and ironmongery damaged are the least defective items arise in architectural work.

Water trap at road, pipe leakage and soil treatment plant defects are the three most defective items occurred in civil and structural works. Meanwhile, air-conditioning is the most problematic item in mechanical works, followed by plumbing and sanitary appliances and ambulance problems. Although electrical is the second highest defective discipline, only one frequent defect i.e lightings not working observed to be occurred compared to biomedical works. There are four frequent defective works in bio medic. However, most of the defects are due to equipment problems and this is still under the warranty and liability of the equipment supplier.

4.2.3 Frequent causes, categories and tracking of defects across the project stages

The types of defects are examined to ascertain on its causes and the frequent causes of defects. Following this, the defect causes are categorised into design, documentation, material, workmanship, lack of protection, maintenance, vandalism and wear and tear. These defects were also tracked into stages of its occurrence and the findings are summarised in Table below.

Table 3: Frequent Causes, Categories and Stages of the Defects Occurrence

Element/Discipline	Frequent Causes of Defects	Categories	Project Stage
A) Architectural works	a) Poor workmanship	Workmanship	Contract
	b) Material selection during design	Material	Pre-Contract
	c) Work in accordance to specification	Workmanship	Contract
	d) Poor design	Design	Pre-Contract
	e) Condensation	a) Workmanship	Contract
		b) Lack of protection	Post Contract
	f) Vandalism	Vandalism	Post Contract

Element/Discipline	Frequent Causes of Defects	Categories	Project Stage
B) Civil and structural works	a) Poor workmanship	Workmanship	Contract
	b) Poor design	Design	Pre-Contract
	c) Lack of supervision	Workmanship	Contract
	d) Vandalism	Vandalism	Post Contract
	e) Work in accordance to specification	Workmanship	Contract
C) Mechanical works	a) Poor workmanship	Workmanship	Contract
	b) Poor maintenance	Maintenance	Post Contract
	c) Poor design	Design	Pre-Contract
	d) Material selection during design	Design	Pre-Contract
	e) Condensation	a) Workmanship	Contract
		b) Lack of protection	Post Contract
		c) Vandalism	Post Contract
D) Electrical works	a) Poor design	Design	Pre-Contract
	b) Vandalism	Vandalism	Post Contract
	c) Poor workmanship	Workmanship	Contract
	d) Work in accordance to specification	Workmanship	Contract
E) Biomedical Works	a) Poor workmanship	Workmanship	Contract
	b) Poor maintenance	Maintenance	Post Contract
	c) Wear and tear	Wear and tear	Post Contract
	d) Vandalism	Vandalism	Post Contract
	e) Poor documentation	Documentation	Pre-Contract

Table 3 illustrates that all defects except electrical defects are frequently caused by poor workmanship. These defects often arise during the contract stage and being categorised as workmanship defaults. Whilst, the defects in electrical works are mostly due to poor design and arise during the pre-contract stage. It is also perceived that there are similarities between civil and electrical works i.e most of the defects are occasionally caused by work in accordance to specification. Meanwhile, vandalism, condensation and poor documentation are identified as the least causes of defects happen in architectural, mechanical and biomedical works. Most of these defects typically arise during post and pre-contract of DB project stage.

5. Discussions

Evidence from the research underlines the significance of implementing a comprehensive DLM system to capture and manage all the defect rectification works undertaken by the DB contractor. Although the numbers of defects identified from each hospital were very large but by implementing this system, all defects were successfully been traced and rectified upon the issuance of CMGD. Despite of managing and supervising the defects, this system also records and documents all the important information on the defects. This information will provides basis for the DB project team to re-learn and improve their existing process for betterment in handling future hospital projects.

One of the means for the project team to re-learn their process is by manipulating the exiting defects data. By reorganizing the data variables, many insights can be obtained to understand the kind of association that exists between the different elements of the defects and the project stage. Findings from section 4, thereby responses to the questions probed by Isa et al, 2010. The industry is now being aware on the root causes of the defects and its stages of occurrence. Consequently, proper action can be made to prevent similar mistakes from being repeated in future hospital projects. While this research only used the frequency analysis, it posits that other statistical test can also be adopted if the data is collected more systematically and categorically.

Within the project context, the findings also suggest that the adequacy of the current DB project implementation process is in question. The study of defects identified during the DLP can be very significant as a control mechanism to ascertain the validity and reliability of a project's implementation process. Without this study there is little that can be achieved to assess whether the project management team has achieved economy, efficiency and effectiveness in their project management process towards achieving zero defects in future projects. Notwithstanding this, proper documentation system should also be organized to ensure that the data is complete and useful in providing reference for the project team.

6. Conclusions

Findings from this research underline the potential for learning from defects if a proper DLM system is in place. With the availability of user friendly and easy-to-use statistical tools, various permutations can be use to classify, capture, record and analyse the defects data to provide usable insights in managing future project. Indeed, there is much that can be learnt if this is made a standard practice for continuous improvement. The study of defects identified from the case study also suggests that results from the defects analysis can provide useful clues to suggest weaknesses in the current DB project implementation system. Finally, there is a possibility for the DLM system to be adopted in a normal project (without the SP appointment) or other procurement method to assist the project team to manage defects during the DLP. However, more studies need to be undertaken to refine the DLM process and proper adaptation should be made to comply with the existing contract variables.

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8. References

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