Towards Implementation of Building Information Modelling in the Construction Industry

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Abstract

The construction industry has been facing a paradigm shift to (i) increase; productivity, efficiency, infrastructure value, quality and sustainability, (ii) reduce; lifecycle costs, lead times and duplications. It is advocated that most of them can be obtained through BIM (Building Information Modelling). It can be defined as the use of the ICT technologies to streamline the building lifecycle processes of a building and its surroundings, to provide a safer and more productive environment for its occupants; and to assert the least possible environmental impact from its existence; and be more operationally efficient for its owners throughout the building lifecycle.

A research study has been carried out to investigate how BIM solutions are implemented by construction stakeholders in the UK, and for this matter investigated on whether a variety of methods being implemented by other countries such as Finland. The study focused on determining key strengths and identifying the challenges involved in implementing BIM in the country. This study was performed by surveys carried out in the UK with the UK construction stakeholders and by interviews carried out in Finland with Finnish construction practitioners and academics. This also captures many other similar studies been conducted by individuals, research groups and organisations around the world during last five years and such content have integrated within this paper as relevant.

Keywords
BIM (Building Information Modelling) implementation, Construction information technology, Information management, Organisation culture, Training and education

1. Introduction

Today in many organisations multi-disciplinary teams are clashing with traditional methodologies (e.g. business models, processes, legal and compensation schemes, etc.) that impede knowledge sharing which cause reinventing the matters and processes on a daily basis. Fragmentation and calcified processes inhibit widespread change in the building industry, which is also traditionally disconnected from lifecycle evaluation methods. However, modelling techniques replaces this fragmented process with an interdisciplinary approach that consolidates the team effort, (Bernstein and Pittman, 2005). It seems the building industry is under pressure to provide value for money, sustainable infrastructure, etc. and hence adaptation of Building Information Modelling (BIM) technology has been inevitable (Mihindu and Arayici, 2008). BIM as a lifecycle evaluation concept seeks to integrate processes throughout the entire lifecycle of a construction project. The focus is to create and reuse consistent digital information by the

stakeholders throughout the lifecycle (Figure 1). BIM incorporate a methodology based around the notion of collaboration between stakeholders using ICT to exchange valuable information throughout the lifecycle. Such collaboration is seen as the answer to the fragmentation that exists within the building industry and has caused various inefficiencies (Jordani, 2008).
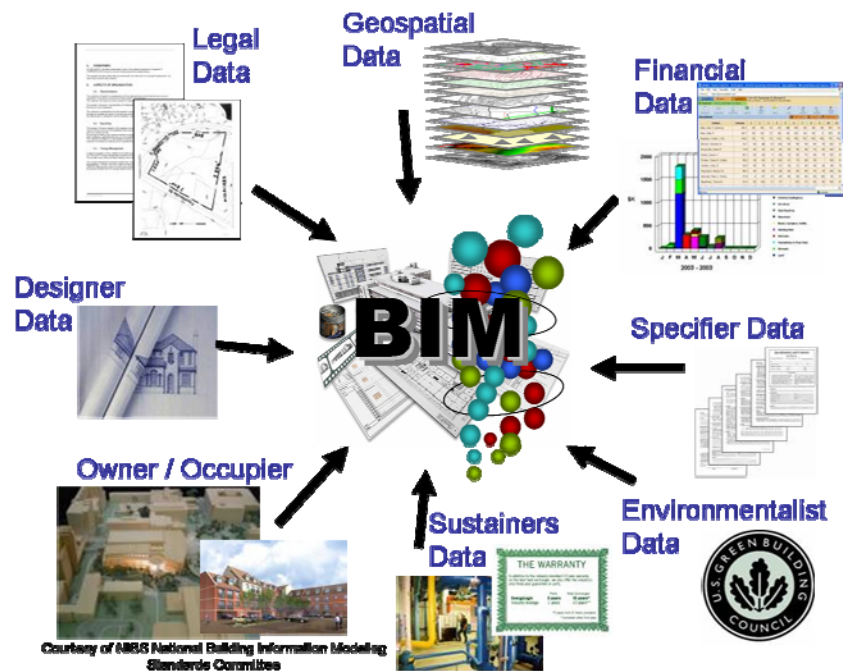

Figure 1: Communication, Collaboration and Visualisation with BIM model (NIBS, 2008)

To date, there are many projects that have utilised BIM systems within; environmental planning, design and development, optimisation, safety and code checking, construction, and have realised its benefits. Such projects have recommended BIM systems as a remedy to address low productivity issues (Mihindu and Arayici, 2008).

2. Lessons Learnt from BIM Implementations

The examples, best practices and the maturity of the process of BIM utilisation in construction projects have been discussed by many researchers (Eastman *et al.*, 2008, Mihindu and Arayici, 2008). Some few key developments over recent years are for example the HUT-600 (Helsinki University of Technology) auditorium extension project in Finland and the construction of Eureka Tower project (2002-2006) in Melbourne with the total of 92 stories (Mihindu and Arayici, 2008).

While many other projects benefited by utilising BIM technology further technological enhancements; new tools, techniques and applications are being researched and best practices are created in many countries. For example, the Building Construction Authority in Singapore developed ePlanCheck system for automating the building code checking for the building assessment and regulatory approval, through an independent platform called FORNAX, which uses the basic BIM information from IFC files to incorporate relevant code checking requirements. This system promotes the designs to be submitted to local authorities in IFC file format. This has become a reference point on how local governments and authorities can utilise BIM within their strategy for the development of built environment (Mihindu and Arayici, 2008).

Over the past six to seven years many pilots and live projects have been completed and documented in Finland, Sweden, Norway, Germany, France, Singapore, UK and Australia, which demonstrated the capability of using BIM within the construction process facilitating construction lifecycle. Many ongoing projects have been proven to develop more environmentally sustainable products, compared to non-BIM based projects. For example, Tocoman Professional Services of Finland (www.tocoman.com) claims that they have facilitated over 200 projects each with reasonable savings due to the utilisation of BIM within building construction lifecycle activities, producing significantly better infrastructures with improved stakeholder satisfaction. The software such as Vicosoft aimed to provide services based on the full lifecycle of the building development much more successfully than other competitive products. However, it will take few more years to learn the importance of such tools by the construction stakeholders due to the risen skill gap (Mihindu and Arayici, 2008).

3. Current Acceptance of BIM in the Industry

In some states such as Finland, Denmark, Norway and USA, the use of BIM has been endorsed, while some other states have progressed toward it. Rapid advancement of some of these activities is discussed briefly. The U.S. General Services Administration (US-GSA, 2008) notified the requirement of utilising IFC model server standards by October 2006. Through conducting 10 pilot projects many BIM authoring tools have been certified as to their fitness for use. Authoring tools; Autodesk's ADT, Autodesk's Revit, Graphisoft's ArchiCAD, Bentley's Architecture, and Onuma Architecture and Master Planning were the initial tools that passed this certification (US-GSA, 2008) and the continual development of modelling requirements proceed further.

Details on IFC version specification, which support each of these tools, were published by Dimyadi (2007). During 2007 National Building Information Model Standard (NBIMS) has initiated another US project, which aimed to raise awareness of using BIM systems and consequently NBIMS has released National BIM Standard Version 1 (NBIMS, 2007). Nevertheless National CAD Standard (NCS) Version 4.0 was released in January 2008 to further streamline design, construction, and facility operations communication among construction stakeholders over the lifecycle. Through improved communication these standards hope to reduce errors and lower costs for all disciplines. It coordinates the efforts of the entire industry by classifying electronic building design data consistently allowing streamlined communication among owners, and design and construction project teams (NIBS, 2008).

BuildingSMART (http://www.iai.org.uk/) was initiated as a Norwegian activity, which followed the IFC compatibility that has been introduced by IAI (http://cig.bre.co.uk/iai_uk/new/index.jsp). Many international chapters of buildingSMART are actively promoting and sharing the latest findings related to BIM implementation within the building product development lifecycle. Today BuildingSMART is an alliance of international organisations within the construction and facilities management industries dedicated to improving processes through active collaboration.

HITOS project of University of Tromso has been one of the well-known international activities that used IFC model server technology (www.epmtechnology.com) in a comprehensive manner. The researchers involved published their assertion that current business processes required to change to gain advantage from BIM (Lê et al., 2006). The Norwegian Directorate of Public Construction and Property, Statsbygg has also produced brief documentation of the project. Statsbygg aims to utilise BIM in all phases, to a complete extent for projects by the year 2010 (Statsbygg, 2007). Further works on BIM and associated IFC files were carried out in the technology programme launched (Value Networks in Construction, 2003-2007) by TEKES focusing on developing eco-efficient solutions for multi-storey and low-rise buildings and provides tools to facilitate the adoption of BIM in construction. During the programme, BIM tools and processes have been developed in order to considerably improve productivity in the industry and make it possible to manage the information generated and maintained throughout the lifecycle of

buildings more efficiently (TEKES, 2008). Finland as the world leader in BIM implementation has 108 projects (TEKES, 2008).

On the other hand, slow progressive changes are taking place within the UK industry whilst many UK companies are happy to continue using traditional CAD. However, it is noticeable that US organisations working in the UK markets are effectively converting their processes to utilise BIM technologies (Oakley, 2008). This conversion requires; training, resources, content creation, team working and new workflows which all need to be managed simultaneously. It is clear within the UK industry that change will not happen overnight; however having a clear strategy along with the correct guidance will enable this process (Oakley, 2008). Lack of cohesive directions from the UK authorities comparable to the discussed international initiatives have created this drag and further research is needed to direct them through meaningful engagement with the industrial bodies to bring the intelligence forward for making the valuable decision to aggressively engage with BIM within the construction projects in a timely manner.

4. Conducting Survey with UK Construction Practitioners and Academics

In order to obtain the UK construction practitioners' approaches and understanding towards BIM for assessing how much the industry has evolved and for measuring the readiness of the industry for BIM implementation, a survey was conducted in a Construct IT workshop. The survey questionnaire was developed through a review of literature on BIM worldwide and through an internal BIM special interest group meetings and discussions in the University of Salford. These questions reflected the concerns highlighted in the literature and provided us with an opportunity assess equivalent issues in UK. Questionnaire for the survey has been circulated to the industry representatives through construct IT network and the survey is still continuing and 17 respondents have returned the filled in questionnaire so far. The extracted survey information will be based on these responses in hand.

The survey questionnaire was comprised of 16 questions, which were divided into 5 categories for systematic analysis. These sections are i) Personal experience and background ii) To recognise the understanding of BIM definition, iii) Barriers and challenges to BIM use, iv) BIM services offered and problems solved, v) Vision and future estimates for BIM use and implementation. In the following sub sections, the survey results for each category are explained.

4.1 Personal Experience and Background of the Respondents

As seen in Figure 2, respondents reflect a broad variation in their number of year of experience. While 8 people have more than 20 years of experience in the industry, 5 people have experience more than 10 years. On the other hand, there is no respondent who has experience between 5 and 9 years but 4 respondents have experience up to 4 years. This means that the overall survey results are dominated by the people who have substantial experience and understanding about the progress of the construction industry over the last two decades. Besides, profiles of the respondents shows a wide range of professional experience and varying specialism in construction such as low-rise buildings, mid-rise buildings, bridges and transportation infrastructure, consultant, airport infrastructure, civil engineering, and IT supply, CAD development, railway, highway, energy, environment and power plant projects. Lastly, the sectors of their construction projects they have been involved in are mainly commercial, residential, governmental, and industrial projects. As a result, the survey result will be able to mirror the views and understanding towards BIM within the UK constructtion industry.
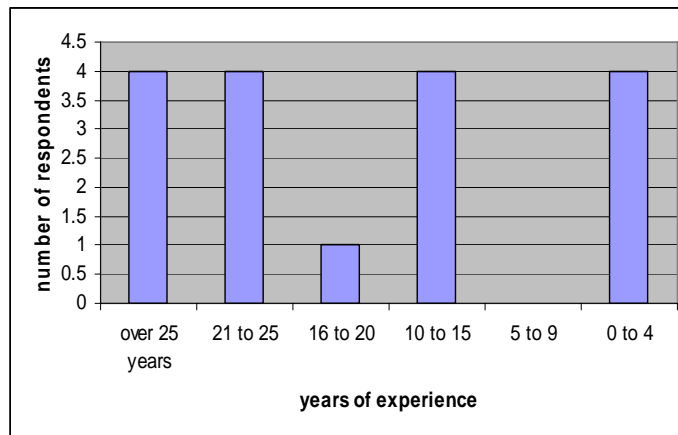
Figure 2: Experience of the Respondents

4.2 Understanding of BIM Definition

Responses to the question about what BIM tools have been used or seen being used shows that traditional CAD vendors such as Autodesk, Bentley and ArchiCAD are most popular ones amongst the users. It can be said that these CAD vendors have taken the lead to introduce BIM to their current users in construction. Although digital project from CATIA, which is initially design for manufacturing and aerospace industry where BIM approach is in place, has a stronger underlying philosophy for BIM, it is not being used very much by the construction practitioners yet. This can be attributable to that the users tend to continue using their current CAD tools by adopting the BIM upgrades from the same CAD vendors.
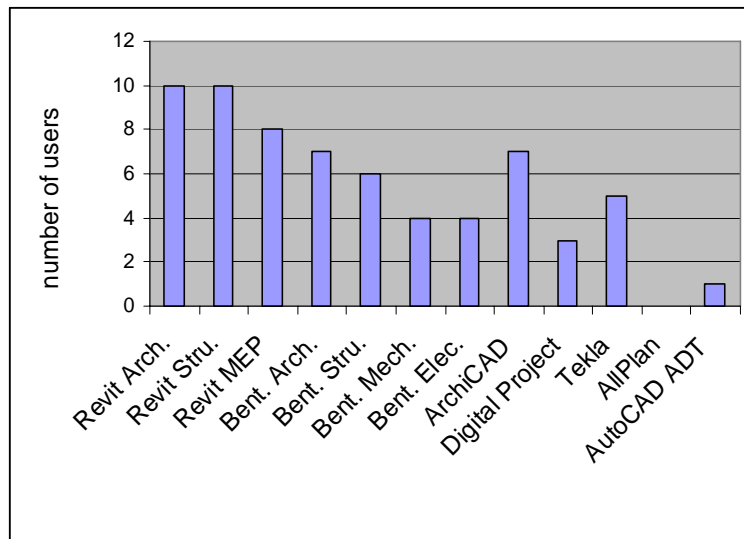

Figure 3: BIM Tools used by the Respondents

Their understanding about BIM is above average. 12 of them identified "*BIM as a 3D modelling, analysis and documentation for the building lifecycle*" whereas three of them defined it as "*using 3D, intelligent, computable data for project collaboration*" and two thinks that BIM is "*creating an intelligent, computable 3D data set*".

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4.3 Barriers and Challenges to BIM Use

From the survey results, it is understood that primary reasons and barriers for not to implement BIM in many UK construction companies are those listed below based on their weighted ranks from the respondents;

1. Firms are not familiar enough with BIM use
2. Reluctance to initiate new workflows, or train staff
3. Firms do not have enough opportunity for BIM implementation
4. Benefits from BIM implementation do not outweigh the costs to implement it
5. Benefits are not tangible enough to warrant its use
6. BIM does not offer enough of a financial gain to warrant its use

On the other hand, it is promising that 35% of respondents stated that their firms have already been implementing BIM and noted no barriers and challenges for BIM implementation. Challenges against the BIM implementation has came out in line with the barriers. It is noted that the respondents have selected some challenges, which are listed below based on the weighting identified through their number of selections by the respondents.

1. Training staff on new process and workflow
2. Training staff on new software and technology
3. Effectively implementing the new process and workflow
4. Establishing the new process, workflow and client expectations
5. Understanding BIM enough to implement it
6. Realizing the value from a financial perspective
7. Understanding and mitigating liability
8. Purchasing software and technology

4.4 Problems Solved Based on the BIM Services Offered

In regard to services offered to clients via BIM implementation, less than 25% of the respondents stated that no extra services to solve any problem were offered to their clients via BIM implementation while some other respondents expressed the services below;

- Construction management
- Third party integration consulting
- Shop drawing production
- Increased efficiency leading to improved design
- Helping clients develop BIM capabilities themselves

On the other hand, it was seen that there was a consensus amongst the respondents in what issues or problems can be overcome by the implementation of BIM within a firm. All the respondents have indicated the aspects below;

- Efficient collaboration amongst the construction stakeholders
- Availability of the accurate documentation of the building development
- Common understanding of project costs, schedule and project progress
- Ability to assess the design alternatives and lifecycle impact
- Reduced error, rework and waste – so towards better sustainability for design and construction

4.5 Vision and Future Estimates for BIM Implementation

All the respondents believed that BIM implementation will result in improving the construction practices. On the other hand, 70% of the respondents believe that fewer than 5% of firms are currently using BIM in UK, while 20% think that 5-10% of construction firms are utilising BIM and 10% of the respondents believe that 11-15% of the UK construction firms are using BIM in construction projects.

However, 40% of the respondents think that 50% of construction firms will use BIM in the construction projects within next five years whereas another 40% of them anticipate that it will last for 5 -10 years from now for 50% of the UK construction firms to use BIM in their construction projects. Finally only 20% think that it will last even longer until 11-15 years from now.

In terms of use of BIM by 90% of the UK construction firms on a regular basis, 50% of the respondents anticipate that it will take 5-10 years. Yet 20% think that it will last for 20 years and 10% envision that it will even take over twenty years to have BIM into the main stream of construction works whereas another 20% believe that it will never happen.

Finally, 80% of the respondents have selected the items in the list below in order for the type of assistance they would like to receive if their firm is to go ahead with BIM uptake over the next one year, while 20% don't need assistance because their firms already using BIM. The aspects below have ranked according to the popularity in the eyes of the respondents, who want assistance in BIM implementation.

1. Clear understanding of benefits that outweigh the cost and other factors
2. Required training and know-how transfer to their firm and staff
3. Attending workshops to discuss BIM uptake and further info
4. Recommendation of a way forward with regards to software and hardware

From the survey result, it is understood that ongoing training, consultancy and support for successful BIM adoption are vital ingredients in achieving a good return on the company's investment. Overall survey results will be interpreted in the conclusion section together with the outcomes from Finnish interviews in a comparative manner.

5. Interviews Conducted in Finland with Finnish Academics and Practitioners

3 academic institutions and 5 private companies from Finland, who have strong interests in BIM have been recently consulted and interviews have been carried out with these 3 academic institutions and with the practitioners from the private companies in Finland in summer 2008. The information collected through the study has facilitated in the creation of a concept map focusing on BIM implementation as shown in Figure 4 below. The concept map holistically shows the findings from the interviews and other associated work. Further, findings from the study have provided a focus on three predominant themes: i) Organisation Culture, ii) Education and Training, and iii) Information Management. The subheadings and inherited parameters within these subheadings are elaborated in detail.
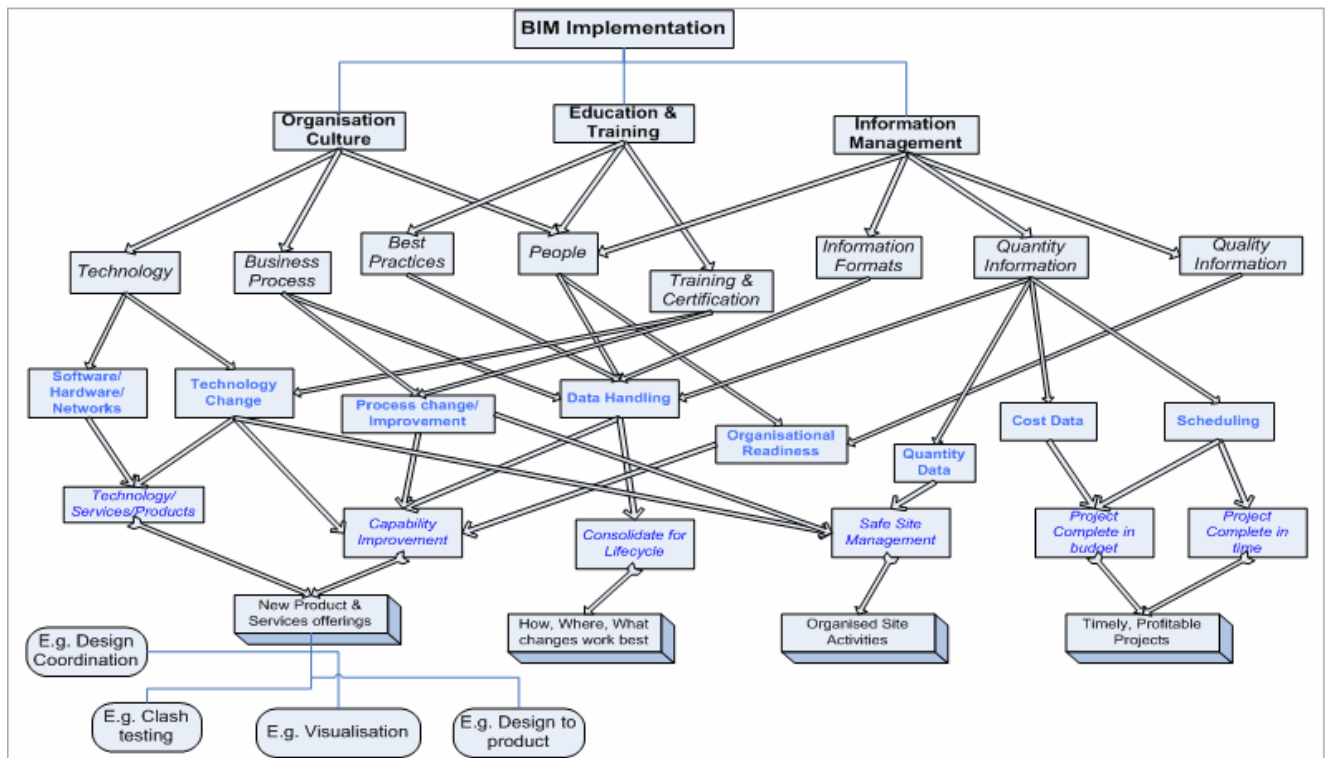
Figure 4: BIM Implementation Concept Map From Interviews conducted in Finland

5.1 Organisation Culture

As noted the organisational culture is predominantly created and practiced by everyone involved in the organisation. Further it is an aspect inherited as the organisation changes, grows and merges. Its affects can be identified within the business process, technologies used and peoples work practices. While these aspects ultimately contribute towards the organisational readiness to accept BIM, peoples' ability, their understanding of the new process, and the availability of the required support including governance are to provide the necessary environment in achieving successful implementation process. BIM implementation has forced technology change and process change within the organisations which will force much improvement of the organisational capabilities or services offerings. In most cases this also involves integration or discontinuation of software and hardware systems within the organisation.

New systems can also provide challenges in data handling which require training within the whole organisation. Due to the nature of BIM, consolidation of data throughout the lifecycle of a given project will be a reality. Therefore many other applications will be able to access such data streams to provide further services, e.g. asset management, demolition management during the lifecycle. In addition, such changes will create new opportunities and improvements, e.g. design coordination, clash testing, virtualisation services and streamlined design to product workflows, which can become a part of the core business process model of the organisation.

5.2 Education and Training

Education and Training has become an important part of BIM implementation due to the process and technological changes within the organisation. In order for the implementation to be successful, all affected people require to be up skilled. Those who are in specific positions may require gaining certain standards of education and training. This is noted as 'certification' on the concept map, however such

standards are not being implemented by training providers currently in regard to BIM. Those who could complete such certification programmes will engage and administer organisational process and technological changes that are initiated through BIM implementation appropriately. Therefore a growing need for such educational programmes to be hosted by academic organisations has been a requirement. Currently only a handful of academic programmes based on such expertise exist around the world, however few more organisations are working towards creating these programmes. Learning of the best practices through professional training is the other important aspect. BIM technology is linked with many other sources of data, e.g. costing, scheduling, and materials flow. However depending on the tools being used such links may or may not be available to a great extent. When the BIM technology is being used appropriately most of such links that show data from building lifecycle becomes visible.

5.3 Information Management

BIM is seen as an efficient information management methodology within construction projects. It heavily involves people's perspective, firstly as creators or collectors of data from the site and other sources, and secondly, as users of processed data, i.e. information or knowledge, from the building models. Different BIM technologies available to date may provide different organisational capabilities and hence the stakeholders are required to assess currently available technologies on the market with necessary concern. This will allow the organisation to select the suitable technology with a futuristic vision, perhaps further services that the organisation is willing to provide in the future. Similarly in some circumstances multiple tools may be required to achieve specific outcomes. Due to variety of software and tools being used many different types of files formats are involved. Here, greater simplicity can be achieved by using integrated products, e.g. vicosoft, tocosoft. Since such tools provide various features with different complexities stakeholders should investigate their recommendation with appropriate future goals. Quantity and quality management has been an important part of such products listed. Quantity data can also assist the appropriate site management feature, e.g. site safety, minimising onsite storage. Costing and scheduling can provide timely project completions with maximum profits/savings.

6. Conclusion

Both the questionnaire based survey and the interviews have highlighted some clear insights. First, BIM implementation undeniably entails change and adoption is not going to be easy for those who are uncomfortable with change. Education and awareness, not just about BIM tools but about BIM in general are critical to tackle the resistance to change. Also, firms implementing BIM are grappling with the fundamental questions of how to reinvent the workflow, how to staff and assign responsibilities, and the modelling process (Khemlani, 2004). Despite the challenges involved in its implementation, after the tedious, redundant, time-consuming, and error-prone world of 2D CAD drafting, the parametric building modelling technology with its automatic document generation and coordination capability, has revitalised the construction professions and brought the innovative design-build process.

BIM can deliver tremendous benefits, but doing so requires a departure from traditional ways of working. Moving from CAD-based technology to object-CAD technology can be an incremental change. Moving to BIM which is different to CAD is a much larger process change, and requires careful implementation planning, staffing, and training. BIM Consultants are to take over this process progressively for realising very important benefits within the industry for creating more sustainable building infrastructures.

Further during this study the importance of interoperability between construction-related applications were identified. Also, such applications are not being produced by traditional BIM design tool suppliers as well as not many other software designers are providing near-term solutions for this course either. This situation has created unprecedented entrepreneurial opportunity for (1) design and development of a suitable BIM Interoperability Suite which integrate most important software being used by the industry,

and (2) offering consultation to construction stakeholders and related organisations on BIM Implementation and Utilisation.

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