IMPLEMENTATION OF BUILDING INFORMATION MODELLING WITHIN CONSTRUCTION SMES

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ABSTRACT

Building Information Modelling (BIM) is promoted as a requisite to improve construction project performance. In the UK, the Government has set the construction industry targets to attain with timescales, such as achieving the BIM Level 2 for all government projects by the year 2016. In terms of the UK construction sector, over 86% of employees work within small and medium sized enterprises (SME), and are responsible for 75% of the turnover. However, BIM implementation within the SME sector is considerably low. As such, SMEs may be left behind in the BIM journey, thereby hindering the policy level targets.

This research was aimed at identifying the key barriers to the implementation of BIM within the construction SMEs in the UK. The data were collected through a literature review, questionnaire survey and four semi-structured interviews.

The findings reveal lack of investment and commitment to resource to skill development in relation to BIM, and the absence of incentives within the government procurement processes as significant among the several barriers to the implementation of BIM within the UK construction SMEs. Despite the UK government's intention that at least 25% of all central government contracts should be awarded to SME businesses by 2015, many construction SME firms are finding it difficult to win public sector work. Therefore, the research findings highlight implications for both policy and practice. For the macro level policy makers, the non-consideration of the diversity and the market dynamics the construction industry may lead to unrealistic policy level targets being developed. For the construction industry and its firms, it is high time to reflect on their current practices and the level of commitment to resource skill development and continuous improvement.

Keywords: *BIM; SMEs; Barriers; Construction Industry; United Kingdom.*

1. INTRODUCTION

The construction industry contributes in average of £100 billion per annum to the UK economy, which represents 7% of GDP (Rhodes, 2015). With the industry being such important and complex (engaging number of stakeholders with different influence and interest), it is important that new methods are constantly developed to respond to the increasing complexity of the construction industry (Bryde *et al.*, 2013). The latest technology introduced to the construction industry is Building Information Modelling (BIM) which has a significant potential to bring positive impacts to the effective delivery of project goals (Poirier *et al*., 2015). BIM provides a robust platform to share and reuse project information, which highly benefit in through-life project management. There are variety of definitions for BIM, however this study adopted BIM as "a set of interacting policies, processes and technologies generating a methodology to manage the essential building design project and data in digital format throughout the building's life-cycle" (Bryde *et al*., 2013, p. 971) as it is closely focused on construction context.

Although BIM is new to the construction industry, its concept has been around since 1970's, dominantly in the manufacturing and engineering sector (Cain, 2003). Construction is always blamed for poor

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performance (Latham, 1994; Egan, 1998). However, it has high potentials to improve as manufacturing and production industries, where there is a clear system in place that visualises the production flow, in which everything is scheduled in advance with all work carried out to an agreed time table, resulting in reduced waste (Bossom 1934 cited by Cain 2003). The report 'Construction 2025' (HM Government, 2013) emphasises the desperate need to restructure the industry through adopting modern methods to its products and processes to make the industry more smart, competitive and efficient. As a result, the UK government has now mandated for a fully collaborative 3D BIM as a minimum by 2016 to be used in all government procured projects.

However, as an industry it is lacking knowledge and experience of how the adoption of BIM can be helped to fulfil the visions of Construction Strategy 2025 (NBS, 2015). Lack of knowledge and understanding on BIM is identified as a key barrier, making it incredibly hard for organisations to get on board; in particular small and medium sized enterprises (SMEs) (Open BIM Network, 2012). SMEs contribute over 99% of the 3.7 million trading businesses in the UK, accounting for two thirds of the construction industry. 52% of these employees are employed by organisations of less than 115 employees and 96% are thought to have less than 8 employees (Federation of Master Builders, 2013; HM Government, 2013). Many researchers and practitioners are still unclear 'why' BIM should be adopted and 'what' are the factors that influence BIM implementation, resulting in its acceptance and use remaining a central concern (Azhar, 2011). Current statistics show the limited implementation of BIM within the construction SMEs UK. This paper aims to identify the significant barriers for implementing BIM within construction SMEs.

2. ADOPTED RESEARCH METHODS

Several methods were adopted to collect data for this study. A literature review was conducted to identify the principles and practices of BIM and further to understand its current application within construction context. An online questionnaire was designed through 'survey monkey' software and distributed among 100 construction industry professionals whose industry experience varies from less than 5 years to over 30 years. The respondents were from different disciplines (architecture, quantity surveying, construction management and engineering disciplines) who workin large to small construction organisations. The response rate to this online questionnaire is 31%. Survey data were analysed through descriptive statistics. In addition, four semi-structured interviews were undertaken among two quantity surveyors, one construction manager and a facilities manager who have already adopted BIM within their practices.

3. BUILDING INFORMATION MODELLING

Building Information Modelling has given number of definitions in the current literature. Eastman *et al.* (2011) explain it as "a novel approach to design, construction, and facilities management, in which a digital representation of the building process is used to facilitate the exchange and interoperability of information in digital format" (Eastman *et al*, 2011). With reference to Smith and Tardif (2009), BIM is an enabling technology with the potential for improving communication, quality of information available for decision making, improving the quality of services delivered, reducing cycle time, and reducing cost at every stage in the life cycle of a building. Having identified the holistic nature of BIM, Bryde *et al.* (2013) explain that not only is it a useful software for geometric modelling of a buildings performance, but also it assists in the management of construction projects with potential to improve collaboration between stakeholders. On average, 70% of the life-cycle cost of a building is established through the decisions made during the design phase (Sebastian, 2010). BIM therefore enables knowledge integration from various project participants who would traditionally work in different phases of the building process to interact and regularly update a central model of the building, therefore producing beneficial project outcomes.

The aim of adopting BIM within the UK construction industry is to maximise client value by increasing benefits with little or no extra cost, by contributing to achieve the goals set out in the Construction Strategy 2025. This relies on integrated design which has also been an important subject in the Construction industry in the UK for the past few decades. The success of BIM rests on the ability of the supply chain changing the processes and culture, work collaboratively to produce such information rich

models (RICS, 2014). Having studied the available definitions for BIM, it is clear that there are some uncertainties as to whether BIM is a new way of working or whether it is highly reliant on merely the software. However, International BIM implementation guide (2014) states "BIM, when combined with issues pertaining to people, processes and organisations, has the potential to significantly impact the industry" (RICS, 2014, p.5). In fact, this confirms that BIM ensures both a new ways of working and also its associated software, so when in practice it is important that both considerations are taken into account in order to gain maximum benefits.

3.1. APPLICATION OF BIM IN MANUFACTURING AND SERVICES INDUSTRIES

BIM has been used for ages in manufacturing, production and services industries. For example, the visual-based product development process, 'Oobeya' (which is a Japanese word for 'big room') developed by the Toyota Motor Company in 1990's to manage information and on the spot decision making (Patrick, Mustapha and Howard, 2012). The tool significantly helped to shorten the product and process development time by managing information, co-ordinate and accelerate cost improvements, monitor progress and bring decisions forward much earlier in the lifecycle (QV System, 2012). This is all done by creating more communication between the people in the different divisions (Frank, 2009). Similar to BIM it manages the entire projects workings of a system through lifecycle.

Similarly, Rolls Royce (car and aero-engine manufacturing company, UK) also introduced 'Optimised Systems and Solutions' (OSyS) mechanism to reduce risk, increase asset availability and improve revenue for their customers, which has been so successful in recent past. For example the system (OSyS) predicts when operationally critical equipment may require out of schedule inspection or maintenance (Rolls Royce, 2010). It also enables proactive resolution of potential issues, improving asset availability and reliability with much better visibility of quality data through a central database which will result in overall savings (Rolls Royce, 2010). Moreover, the OSyS solution is enabled the company to generate and update business plans, achieve growth in the services with 20% fewer staff and 80% reduction in queries. It also provides an opportunity to make informed business decisions to achieve other operational savings (Patrick *et al*., 2012).

3.2. BIM IN CONSTRUCTION INDUSTRY

Being the principal client in the construction industry, the UK Government holds over 40% of the construction output. Therefore, it is important that the Government commit themselves to finding a way to galvanise the industry by exploring modern methods, which will improve the industry performance. In this regards, the Royal Institute of British Architects' (RIBA) attempted to integrate BIM in their Plan of Work 2013. It provides a shared framework for organisations and management of building projects which has been widely used as both a process map and a management tool, reflecting the robust principles in best practice guidance. The RIBA recognises "assembling of right project teams "as one of the most important considerations of any BIM adopted project, which clearly reflects who does what, when and how (Sinclair, 2013). As BIM creates a robust platform for projects to commence as early as possible, this requires a greater degree of clarity to ensure that roles are clearly understood.

BIM enables three-dimensional (3D) models to be created, taking the industry from the drawing board to the computer and ultimately into the digital age (NBS, 2015). BIM levels change emphasis of a project, having all information contained in a single, continuously updated database with the model being the primary tool for documentation (Bryde *et al*., 2013). With the government recognising that the process of moving the construction industry from "independent working" to "collaborative working" involves a lot of dedication and guidance, with clear defined milestones (NBS, 2015). As previously noted, BIM is not only a new technology for the construction industry, but also a new way of working that will change the way in which the stakeholders engage in their role. BIM maturity levels considers stakeholders' contribution throughout the project lifecycle.

Literature argues if BIM is managed correctly, it can become a key enabler of the integrated process, giving unique opportunities for reducing time and cost whilst increasing value. BIM can contribute to effective decision making at the early design and preconstruction stage, involving all parties of the supply chain. The integration of the different parties contributes to reduce both costs and time as errors are able

to be identified during the early stages. It also enables three-dimensional models to be created, providing opportunity for variety of benefits throughout the project lifecycle (Azhar *et al*., 2009). This takes the guess work out of design intent and enables better collaboration which in result improves buildability and innovation (RICS, 2014). On the other hand, early visualisation of the model allows the team to enhance the quality of the project by displaying any weaknesses (Build Offsite, 2013). The project team is able to virtually see how all the systems integrate; architectural, structural, mechanical and electrical. It gives the design team the ability to eliminate duplications of design and a lot of the risks by the detection of clashes; enabling for corrections to be made easily with automatic low level correction through the use of the parametric relationships between objects before construction physically takes place on site (Build Offsite, 2013). The building information model acts as a single source of data. Data from the model can be easily extracted and manipulated. For example being cost estimates which can be done off exact quantity take-offs. This will therefore generate accurate cost estimates of a project before construction stage enabling for fewer overruns (Jayasena and Weddikkara, 2012; NBS, 2015).

3.2.1. BIM IN CONSTRUCTION SMES

Small and Medium Scale Enterprises (SMEs) account for two thirds of the UK construction industry, contributing 99.9% of the UK's trading businesses, with 52% of all employees employed by firms of less than 115 people, 96% are thought to have less than 8 employees (Federation of Master Builders, 2013: HM Government, 2013). Although SMEs dominate the industry in terms of both output and employment, BIM is still not a welcoming practice within the construction SMEs. Many barriers have been identified potentially preventing SMEs from growth, hindering their contribution to the development of sustainability (Open BIM Network, 2012). It can be argued that the desire to raise standards of delivering projects in a much shorter time scale at a higher standard has been at the expense of SMEs (Local Government Task Force, 2007).

Literature explains that the lack of access to funds and modern technology, market conditions and the government regulations as key barriers to the adoption of BIM with in construction SMEs (Miller, 2009). Pickford (2015) highlights that the main challenge for SMEs is not actually spending money on software, it is about them investing their time to truly understand what BIM means to them so that they can have a better understanding of what BIM can do for them. In addition to the results from a pilot survey of one of SMEs concludes that "SMEs engaged in small-scale projects, can adopt relatively simple working methods with basic BIM for direct tangible impacts, without having to radically change their ICT systems or putting their business organisations at stake" (Rizal, 2010, p. 105). Moreover the same study recommends that in order for SMEs to benefit from BIM they need to first establish a sustainable strategy to manage the processes, by optimising the benefits of integrated design and engineering and encourage clients to adopt an integrated procurement method that facilitates a transparent and high-performance collaboration.

SMEs are ideally suited to adopting BIM as they can make decisions and adapt to client/project/industry needs much quicker as they have less employees to catch up on, especially if they have learnt how to use BIM before it really matters on a live project. This could be done by trailing BIM alongside a current project in order to learn without the risks (Pickford, 2015). The National Building Specifications (NBS, 2015) states that they intend to ensure that their programme is well understood and can be adopted by all (irrespective of company size) without barriers. Key to this is the creation of regional hubs which intended to help professionals within the construction industry to learn about BIM and its benefits. Its purpose was to also get valuable feedback from professionals around the world, both using BIM and interested in BIM (Philip, 2012). Alongside the running of the Regional hubs is BIM4SME. BIM4SME is an organisation which is responsible for providing resources, best practice and knowledge to SMEs within the UK to get them ready for the government BIM mandate by 2016 (BIM4SME, 2015). BIM is proving a catalyst for growth for the SME community, helping them to move into new and bigger markets by unlocking new, more efficient ways of working (Smith, 2015).

4. RESULTS AND DISCUSSION

The preliminary data was collected through an online questionnaire survey and four semi-structured interviews among two quantity surveyors, one construction manager and one facilities manager. The response rate for the survey was 31%. The respondents are from construction backgrounds (55% quantity surveyors, 19% contractors, 13% consultants/directorate, 10% engineers and 3% architects). Having analysed the type of organisation that they are working, the result explains that 81% of them work for SMEs and 19% are from the large scale construction organisations. Further analysis says that 55% are private sector organisations, 39% represent public sector and 6% from other or freelance practices. 58% of them are using BIM in their current practices.

The majority of respondents understand BIM as '*information rich 3D model'*, which '*enhance collaborative working' and improves 'project performance'* (in terms of time, cost and quality). More importantly, 62% of respondents agreed that the construction SMEs face number of difficulties when adopting BIM in to their projects. In contrary one of interviewees argues *"as long as SMEs are planning long term and not short term, they will find it just as easy as larger companies, if not easier. SMEs are usually used for short term projects, so they will have the opportunity to use BIM on so many different projects in a short space of time which will boost their experience, of cause depending on if the larger contractor or whoever is employing them are using it"*. Those challenges mainly appear in the areas of 'financial support' 'procurement arrangements', 'engagement, trust and support' and 'knowledge and practice'. Supportively, other three interviewees believe *"SMEs will struggle more as they don't have the required resources specially finances to help them if they get into any trouble during the adoption, also, they tend not to think long term and BIM is definitely something where you need to have a longer term perspective. Trust is a very big issue in the construction industry and without it you can't really expect BIM to work"*.

Having identified the challenges of implementing BIM within construction, the respondents were asked their opinions on how these challenges influence construction SMEs. The study uses 5 scale Likert Scale (0-not sure, 1- strongly disagree, 2-disagree, 3-neither agree nor disagree, 4-agree, 5-strongly agree). The findings explain in Figure 1.

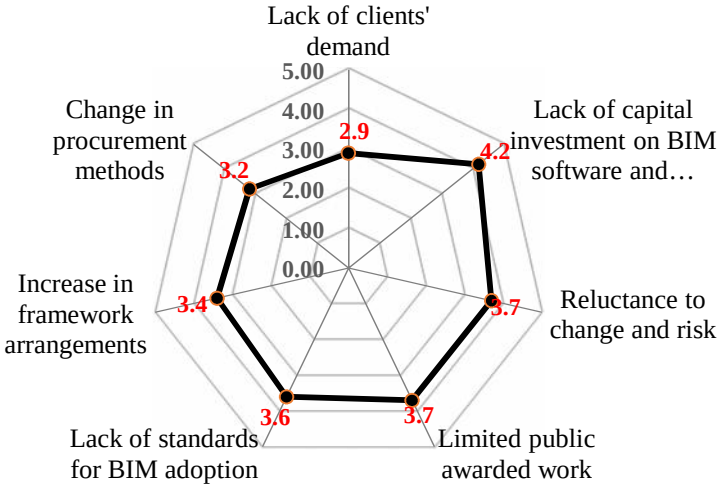

Figure 1: Challenges of Implementing BIM within Construction SMEs

The findings explain 'lack of capital investments on BIM software and training' as the most significant challenge that construction SMEs face when adopting BIM for their projects. Supportively, all the four interviewees explain that *financial aspects have huge implications of whether SMEs will find the adoption of BIM easy or not. Although, again if they plan long term and find that they can adopt it they will be able to have huge benefits.* Moreover 'reluctance to change' from the traditional methods/practices and 'less engagement is public projects' seem as the two of second best challenges. Interviewees identified

'reluctance to change' as a whole industry problem, however two of the four interviewees agreed that *"SMEs who are working for larger organisations so maybe this is due to them not being awarded their own projects which can be risky, if it is only the public sector that is pushing for BIM unless the private sector too start pushing it"*. In most cases, large scale contactors are delivering complete work packages without providing any opportunity for SMEs engage with them. However, one respondent to the survey noted that *"SMEs find BIM adoption easier as they can be much leaner and have less staff to work with; which should ensure that all members are on board and up to a set level of skill"*. Also stating that due to the amount of work they get from larger contractors at once, they may find it much easier to access many BIM projects, gaining more experience with BIM than larger organisations. Importantly another interviewee highlighted *"SMEs are now winning more public work than they did in the past so hopefully that won't be too much of a problem to them now"*. In addition, that 'lack of standards for BIM adoption in construction SMEs', 'increase in framework arrangements' and 'change in procurement method' identified as influential challenges. With compares to other challenges 'lack of client's demand' was given a least impact. Presumably, this will be a positive sign for BIM adoption within construction by assuring the clients awareness on benefits of BIM. In addition to aforesaid challenges, few respondents were noted 'main contractors self-delivering', 'unrealistic expectations', 'no clear direction' and 'lack of expertise' as other influential barriers to implement BIM within construction SMEs.

Moreover, the findings highlighted *financial concessions*, *support on BIM training and awareness programmes*, *opportunities for winning more public projects*, incentive-*penalty schemes* as the way ahead for encouraging SMEs to adopt BIM in their practice.

5. CONCLUSIONS

The barriers preventing construction SMEs to adopt BIM were revealed through this paper.

BIM has been described as a new way of working in the 21st century, which will bring many benefits to the construction industry. However, it has been widely argued that there are number of challenges, when it comes to implement within the construction SMEs. The results noted that the construction SMEs lacks the required knowledge and competencies on BIM, however until they gain such maturity they are reluctant to implement BIM within their practices. The key challenges appear in the lack of capital investment on software and training, limited public awarded work and reluctance to change.

The results explain SMEs are not being completely aware of BIM, and the cost implications, could mean that they have yet to implement a strategy to finance the adoption, so decisions could be prone to change when this awareness does reach the surface. Although not all SMEs have adopted BIM, it is important that they plan long-term and set targets to put themselves in a position to adopt BIM within their practices. It is highly recommended that the government should take initial actions on supporting the SMEs (through training, awareness programmes, standards and reforms) in hope to encourage them to integrate BIM within their professions. However, as SMEs contribute to the vast majority of the construction industry, it is highly unlikely that the government will fully endure such expenses but the concession schemes can be introduced. On the other hand, the limited public awarded work for SMEs is also identified as a key barrier to implement BIM within their practices. Therefore, it is worthy if future studies could focus on whether new reforms to the PQQ (pre-qualification questionnaire) have contributed to SMEs gaining more work within the public sector.

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