CHALLENGES TO BUILDING INFORMATION MODELLING IMPLEMENTATION IN UK: DESIGNERS' PERSPECTIVES

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Building information modelling (BIM) has been proposed as a technology enabled process for the realisation of the performance ambitions of the construction industry through integrated management of information in virtual 3-D formats. Significant challenges however exist which undermine its implementation within the construction industry. The identification of these challenges is an imperative precondition for successful implementation of BIM given the associated risk. The design phase has particularly been cited as a significant beneficiary of process improvement and efficiency gains expected from the deployment of BIM. Despite the critical role of the design phase to project delivery and consequently BIM usage, few studies have sought to interrogate the challenges faced by designers. A qualitative approach was adopted through semi-structured interviews to solicit perspectives of UK design firms on the implementation challenges being faced. Findings reveal a categorisation of challenges as design-specific, team-orientated, project-related, technology related (BIM specific), industry-wide challenges and cost. This categorisation is used as a basis for identifying critical challenges which include: design process lag and loss of time; lack of understanding by clients regarding requirements for the BIM model; lack of learning feedback from projects on which BIM has been used; and lack of supply chain integration. Variation in the challenges across different maturity levels of firms is also confirmed in this study, particularly in relation to cost of implementation. Awareness of these challenges provides opportunities for identifying effective solutions for their mitigation.

Keywords: BIM, designers, qualitative research.

INTRODUCTION

For the past two (2) decades, effective and efficient delivery have been a major challenge within the construction industry, with fragmentation being one of the key contributors to the under-performance in the delivery process (Latham, 1994; Egan, 1998; Cabinet Office, 2011). Some of the cited performance issues include: lack of cost and time certainty in the delivery process; quality of finished product; adversarial culture; unmanageably delegated risks and rewards (Latham, 1994; Egan, 1998). Lack of integration within a loosely coupled project delivery process prevents effective communication and collaboration towards aligning the interests of project participants and streamlining project delivery into a single well-co-ordinated process

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(Egan, 1998). Such a process, underpinned by effective information and knowledge sharing which is enabled by the application of information and communication technology (ICT), is being promoted as one of the key catalyst towards improvement within the construction industry (Arayici *et al*., 2012a). More recently a new process related to innovation underpinned by virtual 3-D communications has emerged promising to revolutionise the extent of integration and collaboration within the project delivery process (Eastman *et al*., 2011; Arayici *et al*., 2012a). This innovation referred to as building information modelling (BIM), is defined as a *"process involving the structured sharing and coordination of digital information about a building throughout the lifecycle"* (Eastman *et al*., 2011).

In the UK, the Government construction strategy (Cabinet Office, 2011) has given greater impetus to BIM adoption with the expectation of realising a host of benefits. Full realisation of benefits however relies on an industry-wide adoption of BIM which however appears to be fraught with several challenges. This study looks into the challenges to BIM usage from the perspective of designers. In the sections that follow, a background literature review on BIM covering developments on BIM, its benefits and implementation challenges is presented. Subsequently the research method adopted for this study, and the resulting findings and conclusions are presented.

LITERATURE REVIEW

BIM is regarded as a collaborative technology that achieves the levels of integration envisaged as being capable of eliminating most of the communication related delivery challenges of the industry (Eastman *et al*., 2011). Although it has been in existence for decades (van Nederveen and Tolman, 1992), it has only been popularly used in recent years (Eastman *et al*., 2011). In the UK, BIM is more widely discussed due to the Government's construction strategy to implement BIM level 2 on all government projects by 2016 in a road map towards universal adoption of BIM across the industry (Cabinet Office, 2011). Government's expectation includes the delivery of efficiency, improved carbon performance and up to 20% cost reduction on public projects through systematic adoption of BIM (Cabinet Office, 2011). It is expected that the achievement of these targets will be delivered via the benefits associated with BIM. The realisation of these benefits is however being undermined by several socio-technical issues. The following sections discuss these issues together with the benefits of BIM.

BIM Benefits

The benefits of implementing BIM in a construction project are copious. They include: early collaborative decision-making; increased design clarity; strong link between design and costs; early virtual prototyping; improved visualisations and simulations; reduced waste; decreased errors in documents; reduced costs; better construction outcomes; higher predictability of performance; and real-time data sharing between all disciplines from cradle to grave (Suermann, 2009; Azhar, 2011; Bryde *et al*., 2013). Beyond these are also specific benefits to the various project participants. Clients are expected to benefit from better requirement capturing due to enhanced communication with the design team (Eastman *et al*., 2011; Arayici *et al*., 2012b). Designers are also expected to achieve increased clarity in design intent, easy testing of design options, and easy distribution of design documentation across the teams (Arayici *et al*., 2011; Azhar, 2011). Benefits to contractors include access to better quality information for estimation and bidding; early involvement to contribute to constructability and effective scheduling; and clash free construction due to ability

to simulate before actual construction (Suermann, 2009; Sebastian, 2010). Some benefits attributed to facilities management include enhanced quality of as-built and handing-over information, and easier integration into computer aided facilities management (CAFM) systems for maintenance and post occupancy assessments (Azhar, 2011; Arayici *et al*., 2012b). Despite the touted and sometimes demonstrated benefits from case studies, there are fundamental socio-technical issues which continue to decelerate the industry's wider adoption and implementation of BIM (Bernstein and Pittman, 2005; Arayici *et al*., 2012a).

BIM Challenges

Many of the challenges contributing to slow adoption of BIM have widely been reported from various viewpoints. According to Newton and Chileshe (2012, pp.3-12), the most highly-ranked challenges, based on a survey in the Australian construction industry are: 'lack of understanding about BIM', 'education and training costs', 'start-up costs' and 'changing the way firms do business'. The high expectation of information sharing requires organisational interoperability. This is often regarded as a contributory factor to legal challenges and possible disputes emanating from ambiguity about data ownership, copyright and data protection (Azhar, 2011). Some other reported challenges include: overcoming the endemic resistance to change; adaptation to traditional and existing processes and task workflows; and awareness and clear understanding of the responsibilities of different actors in a typical project organisation (Eastman *et al*., 2011; Arayici *et al*., 2011; 2012a). Authority and control over information involving diverse parties has been cited as a key challenge (Davies and Harty, 2013). There is also some uncertainty as to who to bare the associated costs of implementation (Azhar, 2011). Some of the challenges have also been attributed to relatively low capacity, capability and extent of development of BIM related technologies. This includes lack of information technology (IT) resources and network capability to run BIM applications competently (Eastman *et al*., 2011; Singh *et al*., 2011). Lack of interoperability due to a lack of standardised approaches to sharing data across diverse proprietary information systems and software is seen as a major challenge (Eastman *et al*., 2011; Gu and London, 2010). The general unavailability of vendor-neutral data formats and standards, as well as issues regarding accessibility and security of data are challenges yet to be appropriately addressed (Singh *et al*., 2011; Mahamadu *et al*., 2013). According to Fischer and Kunz (2006) the lack of awareness or promotion through standardised guidelines and implementation support impedes successful adoption. BIM specific requirements are yet to be adequately embedded within current state of procurement and legal structures in order to alleviate some of the above-mentioned challenges (McAdam, 2010).

The above discussion demonstrates that BIM implementation challenges have been a subject of considerable attention. However, in the main, studies which have reported on BIM implementation challenges have not done so with an in-depth focus on a specific profession/project participant. Despite the emergence of discipline/profession-specific studies in relation to BIM implementation (e.g. BCIS, 2011), few of such studies have focused on an in-depth analysis of challenges.

Towards interrogating profession-specific challenges of BIM implementation

Whereas the benefits of BIM to various construction professions/project participants have been widely reported (see Sebastian, 2010; Bryde *et al*., 2013), similar profession/project participant focus on the challenges has not gain much research attention. A few of the studies which have explored profession-specific challenges

include works by Williams (2013) and BCIS (2011) which provide some insights from the perspective of facilities managers, quantity surveyors and building surveyors. The need for profession/project participant-specific studies has been highlighted by several industry BIM surveys (within and outside UK) which indicate significantly varied levels of BIM awareness and perceptions of BIM challenges across various professions (see McGraw-Hill Construction, 2010; NBS, 2012). Other studies have also highlighted the role of contextual profession-specific attributes such as industrial norms and environmental settings within which each profession operates as determinants of their perceptions about BIM (Jacobsson and Linderoth, 2010; Davies and Harty, 2013). Such professional dispositions and perceptions invariable affect adoptability as a result of variations in readiness, capability, and maturity of these professions (Jacobsson and Linderoth, 2010; Davies and Harty, 2013).

In summary, the foregoing discussion points to the need for further studies to explore profession-specific challenges to BIM implementation. Given that the various professions/project participants will have to engage with BIM within their respective functions/roles (albeit in a collaborative manner), it is crucial to identify any challenges these professions/project participants may be encountering.

The need to explore challenges being faced by designers

In exploring profession/project participant-specific issues regarding BIM implementation, it is worth interrogating the challenges being experienced by designers. It is well established that the most important project decisions are often made during the design stage which has significant impacts on the subsequent stages of a project (Uher and Loosemore, 2004). For instance, it is estimated that approximately 70% to 80% of a project's lifecycle costs are determined during the design phase (Mileham *et al*., 1992). Also decisions made during the design phase have a significant impact on other project outcomes such as health and safety (Manu *et al*., 2012; 2014). Undoubtedly, design decisions are thus crucial in project delivery. The profound significance of decisions by designers makes any efforts towards facilitating BIM implementation by designers very vital, hence the need for in-depth exploration of designer challenges to BIM implementation. This research therefore aimed at investigating the challenges faced by designers (i.e. design firms) in the implementation of BIM within the UK construction industry.

METHODOLOGY

The research aim of exploring the challenges to BIM implementation for a specific context (i.e. designers) requires exploration of personal opinions, experiences and knowledge within the domain. Qualitative research is capable of providing the opportunity to discover any peculiarities to designers from their opinions, impressions and experiences through in-depth examination of issues (Hartman *et al*., 2009). Adriaanse (2007) cited methodological issues (i.e. over-reliance on quantitative and positivist perspectives) as a cause of limited explanatory powers of current knowledge on adoption of IT within the construction industry. In view of the 'novelty' of BIM, it is recommended that more qualitative approaches are deployed to explore context to greater depths (Hartman *et al*., 2009). More recently, studies employing qualitative approaches are beginning to emerge (e.g. Adriaanse, 2007; Harty, 2012). Such qualitative studies are better positioned to aid inductive development of theory and conceptual propositions on adoption which is vital in view of the 'novelty' of BIM (Hartman *et al*., 2009). For this study, qualitative interviews (semi-structured) were used to collect data from design firms. The interviews were designed to probe their

perceptions, attitudes and experiences relating to challenges faced in implementing BIM. To obtain the participation of design firms (i.e. architectural and engineering), invitations were sent to 60 design firms operating within the London region of UK. Out of these, the participation of 10 firms was obtained. The profile of the firms and the interviewees within them are shown in Table 1. The interviews were audio-recorded and subsequently transcribed and cross-checked to correct any errors. The transcripts were read and re-read iteratively and coded with the aid of QSR NVivo 10 leading to the generation of themes.

Table 1: Profile of design firms

Firms	*Type of Design Firm*	*Size of Firm (by no. of employees)**	*Approximate Years of BIM usage experience*	*Role of Interviewee with Firm*
A	Engineering Design	Large	7 years	Structural CAD technician
B	Architectural and Engineering Design	Large	7 years	Digital Design Representative
C	Transport Systems	Large	None	Project engineer
D	Architectural	Large	9 years	Applications Administrator and BIM Manager
E	Architectural	Small	1 year	Architect
F	Engineering Services, Facilities and Energy Management	Large	12 years	Engineering and Energy Director
G	Architectural	Large	None	CAD and Design Manager
H	Architectural	Large	2 years	BIM Manager
I	Architectural and Interior Design	Medium	0.5 years	BIM Manager and Design Team Lead
J	Architectural	Small	1 year	Architect

*Firm size: mirco < 10, small < 50 employees, medium < 250 employees, and large ≥ 250 employees (European Commission, 2005).

As shown by Table 1 above, the firms include architectural and engineering design firms. The firms vary in size and they also have varying years of experience of BIM usage. These variations enriched the data in terms of providing the opportunity to explore differences in the perceptions or experiences of BIM challenges.

FINDINGS AND DISCUSSION

The analysis resulted in the categorisation of challenges in key thematic areas. It was emergent that the challenges could be classified as: Design-specific, inference to challenges faced by the designers that are very specific to design tasks and suitability of BIM for undertaking them; Team-oriented (i.e. challenges faced by the designers in relation to teamwork, collaboration and cooperation with other project participants); Project-related (i.e. challenges related to temporal organisation rhetoric of the construction industry as well as barriers related to the delivery of individual projects rather than business within the firms); Industry-related (i.e. challenges related to barriers imposed by wider industry conditions including frameworks for supporting BIM implementation); BIM specific (i.e. challenges related to the inherent characteristics of BIM technologies including software and infrastructure issues); and lastly challenges pertaining to the Cost of adopting BIM. The emerging issues are discussed in these thematic areas. The discussion is also interspersed with sample

quotations from the interviews to demonstrate grounding of the findings in the interviewees' own words.

Design-specific challenges

A critical challenge highlighted by participants was that *"people are used to working in much simpler ways where lines are just lines and they aren't 3D objects"* [Firm D - Applications Administrator and BIM Manager]. It was also commented that BIM is *"a massive system overhaul where you have to completely change the work and all the processes"* [Firm A-Structural CAD technician]. This challenge is also mentioned in literature as changing the way firms do business (Newton and Chileshe, 2012) and adaptation to new process (Arayici *et al*., 2011). Tailored training to accommodate the necessary process redesign was viewed as a key issue similarly reported by Newton and Chileshe (2012). Another design-specific challenge is the loss of time and lag in the design process resulting from setting up of the BIM model and passing it between different team members. Commenting on this, an interviewee for instance mentioned that, *"The initial creation of the model - that is very different. You need a lot more time to build up the model with a lot more information upfront, time to go away and do the modelling. Whereas before you would draw up the CAD drawings as the information was fed through"* [Frim A - Structural CAD technician].

Team-orientated challenges

These challenges include: a lack of understanding by clients regarding their requirements for the BIM model, problems with facilities management, and supply chain congruence on the manner in which to engage with BIM. Examples of interviewee comments reflecting these are:

"It is a problem when certain companies use BIM only commercially in the business development angle rather than from a process and system development angle." [Firm F - Engineering and Energy Director].

"The clients need to be further educated on BIM so that they know what to expect but currently they don't understand enough" [Firm D – Applications Administrator and BIM manager]

Within literature, similar issues that prevent the ability of actors across the entire delivery process to effectively integrate have been highlighted (Gu and London, 2010; Harty, 2012; Newton and Chileshe, 2012). For instance, Azhar (2011) mentioned that facilities managers usually have limited involvement in the early phases of projects, despite the advent of BIM. This is indicative of structural and industrial norms which may still be impeding effective collaboration in spite of the integrative communication capabilities of BIM. Additionally, uncertainty by clients has also been noted in literature (Cabinet Office, 2011). Another challenge is the lack of integration from the supply chain as some manufacturers are not convinced that investing in BIM in the UK will be a worthwhile investment. In view of this it was mentioned that, *"Another challenge is supply chain integration whereby a big problem is with major international manufacturers where the UK is a fairly small proportion of their business, therefore for them to invest in UK-centric BIM would not add value to them."* [Firm F - Engineering and Energy Director].

Project-related challenges

The project-related challenges that surfaced from the interviews are insurance and uncertainty of chosen route to implement BIM through existing project procurement

strategies. A comment relating to this is: *"Intellectual property, who owns the risks and responsibilities, can be difficult to determine due to the level of sharing on BIM. We find ourselves outside our level of insurance at times just because the insurance hasn't adapted to the new ways by which people are having to work."* [Firm I - BIM Manager and Design Team Leader]. Azhar (2011) also highlight that BIM creates further risks and liabilities due to indistinct responsibilities of every project member where errors will be difficult to determine and prove.

Industry-related challenges

It was expressed that project deliverables (i.e. drawings) need to be modified from a contractual perspective and that there is lack of clear guidelines and standards for implementing BIM. The latter challenge is even more pronounced among large multinational firms where due to different requirements in different countries, it is difficult for them to standardise their work. Whilst it was mentioned that existing guidelines and standards require further clarity, it was also acknowledged that they have some usefulness. Another challenge is the lack of adequate learning feedback from projects on which BIM has been used. It was felt that such feedback is important in improving the understanding of BIM amongst project participants and that it is also important in informing investment decision regarding BIM. A selection of the interviewee comments relating to the industry-related challenges are:

"One of the larger issues for the industry is that the requirements are changing but the deliverables haven't changed from a contractual perspective. Until 2D deliverables are gone or at least refined, we are going to have a lot of problems. Until the system changes, the deliverables change, and it is contractually obligated to use BIM, there will be a challenge." [Firm D - Applications Administrator and BIM Manager]

"Due to the lack of learning feedback, we are struggling to understand" [Firm F – Engineering and Energy Director]

"With a large company like ours where firms are worldwide, it is difficult to standardise work as they all have different requirements in different countries" [Firm D - Applications Administrator and BIM Manager]

The Government has provided significant leadership and promotion of BIM through frameworks and guidance (Cabinet Office, 2011; NBS, 2012). It has however been reported that some of these remain inconsistent or have not been effectively synergised within existing procurement practices and related documentation (McAdam, 2010). The implementation challenges have similarly been attributed to lack of case studies to serve as benchmarks and knowledge base for training and implementation guidance (Gu and London, 2010).

BIM-specific (technology) challenges

There were challenges faced by the designers that are specifically related to the BIM technology itself as evident by comments such as, *"There is still anxiety generally for people to use it."* [Firm J - Architect]. Such anxiety is related to the complexity and lack of understanding surrounding BIM (see Newton and Chileshe, 2012). It is also reported in the literature that adopting a new integrated technology in general is a challenge due to coordination and interoperability of different software packages (see Bernstein and Pittman, 2005) and the lack of designers who are competent and conversant with BIM (Harty, 2012). The issue of interoperability was again highlighted in the interviews as shown by the quote below.

"There are a lot of different disciplines that use different bits of software. Historically, architects tend to use Microstation, a Bentley product; structures tend to use Autodesk Revit or AutoCAD, so there are rival companies. The barrier is getting the completely two different bits of software to talk to each other effectively."[Firm A - Structural CAD technician].

BIM cost challenge

The cost of implementing BIM as a firm was considered to include: software cost; hardware cost; training cost; hiring new employees with BIM competence; and hiring an external BIM consultant. Whilst some of these costs (e.g. software cost) are easy to quantify in monetary terms, costs relating to the process of up-skilling employees is more difficult to estimate. In particular, it is difficult to quantify the cost relating to the reduction in employees' productivity as they learn to become conversant with BIM. Also, whilst cost of implementing BIM appeared to be a main concern for the small firms, cost did not seem a prioritised challenge to the large firms. Below are sample quotes regarding the cost of BIM implementation.

"We did have to upgrade some of the older computers with enough power to run all the CAD programs, graphics and BIM." [Firm H - BIM Manager]

"The cost that can't be easily quantified is the drop in the employee's productivity while they get up to speed in learning the software… The cost of the learning curve is difficult to quantify." [Firm I - BIM Manager and Design Team Leader]

The costs of implementing BIM are also accentuated in literature as a challenge by Azhar (2011).

CONCLUSIONS

Previous studies on BIM have, in the main, not accorded much attention to in-depth exploration of challenges being faced by specific industry professional groups/project participants. Contributing to these studies, this research has explored BIM adoption and implementation challenges particularly from the perspective of designers. Key challenges identified include: cost of deployment especially in the case of small design firms; changes to existing ways/processes of designing; process lag and loss of time due to the creation of the BIM model and passing it between other project participants; lack of understanding by clients; lack of learning feedback; issues of interoperability; lack of supply chain integration; and lack of clear guidelines and standards. Whilst some of these challenge share similarity with other challenges reported in previous studies, the specific profession (i.e. designers) focus given by this study provides further opportunity for exploring and identifying tailored solutions to address the challenges being faced by this professional group.

Furthermore, in view of the criticality of the cost of BIM implementation, especially to small design firms, the existence of thorough cost-benefit assessments to evidence return on investment (in the short and long term) would be useful to facilitate decision-making.

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