DOES SIZE MATTER? EXPERIENCES AND PERSPECTIVES OF BIM IMPLEMENTATION FROM LARGE AND SME CONSTRUCTION CONTRACTORS

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> *"The idea that BIM is only for big busine*ss is challenged by the growing number of *small and medium enterprises (SMEs) that can demonstrate a return on investment"* (NBS, 2012)

This paper presents the findings of a qualitative study into the experiences and perspectives of large and SME construction contractors towards the implementation of Building Information Modelling (BIM) within their organisations. Results of the survey were statistically analysed to test for similarity and significant variations between the two groups. The results confirmed that both groups were equally aware of the perceived benefits of BIM, but found that the largest barriers to implementation were the costs associated with the technology and training requirements. Significant differences between the groups included plans to implement BIM and concerns with legal and commercial barriers.

Keywords: BIM, BIM-adoption, BIM-Barriers, BIM-Benefits, Organisation Size.

INTRODUCTION

Following long term concerns over construction industry fragmentation, inefficiencies and waste, Latham (1994), quantified the cost of inefficiency and waste in the industry as being 30% and attempted to persuade clients to actively lead an industry reform movement. Egan (1998) subsequently identified global areas for improvement estimating that only 40-60% of potential labour efficiencies are ever achieved, up to 30% of the cost of construction is due to rework; 10% is due to material wastage, and accidents could account for as much as 3-6% of total project costs. Egan (1998) also highlighted promising developments such as lean processes, the use of standardisation and pre-assembly methods, and "new technology such as 3D object-oriented modelling and global positioning systems".

Cain (2003) argued that these earlier reports failed to have significant impact because the industry continued to be unwilling to measure its own performance. Wolstenholme, (2009) reviewed industry progress made a decade after the publication of Rethinking Construction (Egan, 1998) and concluded that the industry failed to meet several of Egan's targets of cutting capital costs by 10%, improving predictability and productivity by 10% and eradicating defects and accidents on site by 20%, and the targets that had been met, such as increased profits were achieved

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primarily as a result of a buoyant global economy, rather than resultant improvements in company and project performance.

"Egan had a big impact on some parts of the industry but the transformation remains incomplete. For the last decade, the construction industry has been sheltered by a strong economy. The current economic crisis is the perfect opportunity for us to restart the process and create a built environment sector this country deserves" (Wolstenholme, 2009).

Recent industry performance, the economy and the government as change agent.

The 2011 Construction Industry Key Performance Indicators (KPIs) revealed that 55% of current projects are delivered late and 37% are not delivered to the intended budget (Constructing-Excellence, 2011). Crotty, (2012) argued that poor quality of information results in this failure to deliver projects predictably, to required quality, on time and within budget. Clearly then, adopting BIM into the working practices of all organisations in the construction supply chain should result in clear process improvements. This however requires initial investment (CRI, 2011) that few are comfortable with providing during a period of economic instability. The impact of recent periods of UK economic recession between 2008-2009 and 2011-2012 resulted in (amongst other things) fewer projects; increased competition for available work; cash flow difficulties; loss of profits and turnover; reduced training; rising unemployment; salary cuts or freezes; downsizing and more stress for construction professionals (CIC, 2010; CIOB, 2010). Figures from April 2012 released by the Office for National Statistics showed a further fall in construction output of 8.5% between 2012 and 2011 (Withers, 2012), which has also provided the perfect excuse for organisations not to implement BIM as it is seen as "still a step too far for many who are currently engaged in back-to-basics contracting" (Knutt, 2012). In contrast Harding, (2010) believes "this economic crisis can be used to achieve what Latham and Egan were prevented from doing". Bew (2010) points out most innovation is carried out when the market tightens and businesses are faced with survival options, not through client pressure as, unlike the automotive or aerospace markets, in the construction industry there is no one private sector client believed to be able to substantially affect the market. One client clearly in the mood for change, who is capable of accelerating change is the UK government whose chief construction adviser initially Paul Morrell dismissed recommendations of BIM being used only on projects over £50m within the Low Carbon Construction report (IGT, 2010) as "unambitious" and qualified that the use of Building Information Modelling would be made mandatory on virtually all government projects down to a lower level of £5m within five years (Withers & Matthews, 2011).

In 2011 two significant government documents were issued, the first detailed the progress and findings of the BIM Industry Working Group looking at the construction and post-occupancy benefits of BIM and recommended a strategy to increase BIM take-up over a five year period (BIM Industry Working Group, 2011) The recommendations of the Working Group were to adopt the "Push-Pull" strategy with the government supporting the "Push" supply side of the industry to enable all players to reach a minimum performance of Level 2 in the area of BIM by 2016 (see figure 1). With the "Pull" being from the client side in specifying, collecting and using the derived information in a value adding way over a similar timescale.

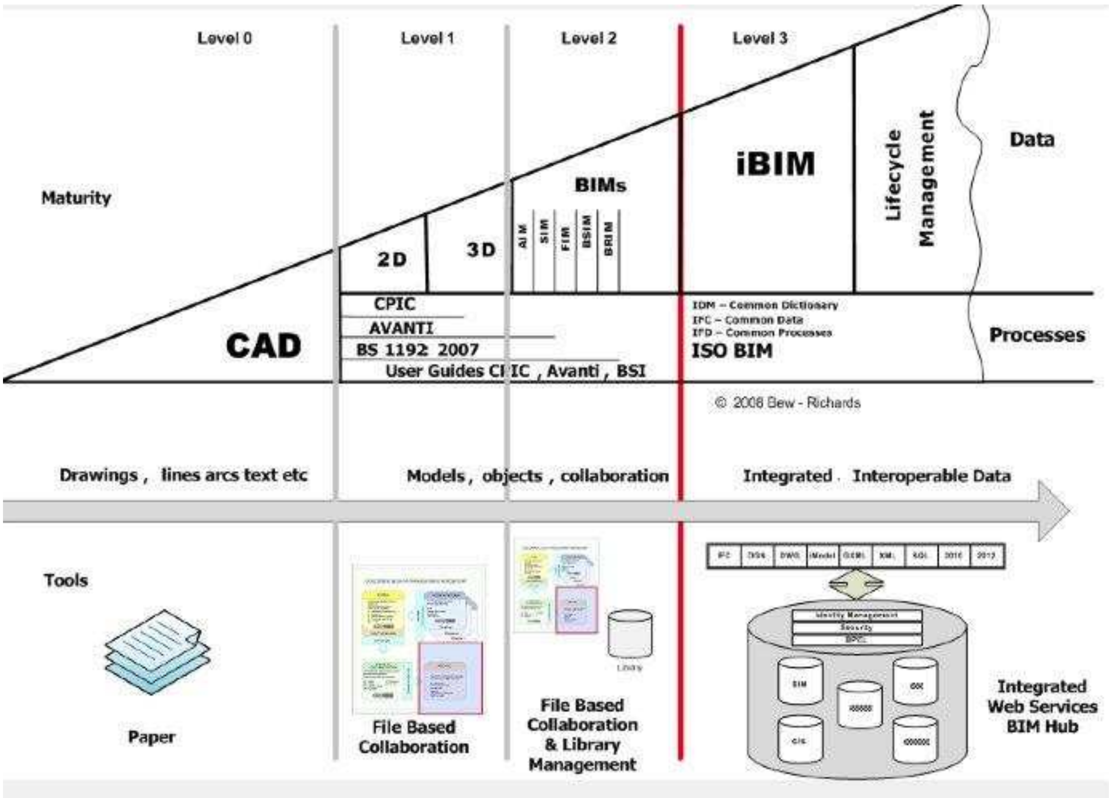

Figure 1: BIM Maturity Level Definitions (Bim Industry Working Group, 2011)

This document was followed by the official Government Construction Strategy, which detailed measures to be taken in order to reduce costs by a targeted 20% in the construction of public sector facilities recalling aims familiar to previous industry improvement reports, including:

High quality briefing documentation focusing upon performance and outcome

Collaborative working developing integrated solutions to best meet required outcomes

Early design input of key supply chain members to create value

No reliance upon lump sum tenders based on inadequate documentation

Serial supply chains arrangements where possible

Research and innovation around standardised (or mass customised) products

Provide industry with sufficient visibility of the forward programme to make informed choices

Aligning interests of designers/constructors and occupiers/manage of the built facility.

List adapted from the Government Construction Strategy (2011)

The Government Construction Strategy document incorporated the recommendations of the BIM Industry Working Group, acknowledging that "whilst some companies have the capability of working in a fully *collaborative 3D environment … (the* construction industry) has generally lagged behind other industries in the adoption of the full potential offered by digital technology". The document also provided confirmation that "Government will require fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016" and that the Cabinet Office would "*coordinate the Government's* drive to the development of standards enabling all members of the supply chain to *work collaboratively through Building Information Modelling (BIM) … (through) a* phased process working closely with industry groups, in order to allow time for industry to prepare for the development of new standards and for training" (Cabinet Office, 2011).

Benefits of implementation.

Considerable waste and avoidable cost result from both the traditional 2D environment and un-coordinated 3D design due to human error which often results in re-work (Love, Edwards, Han, & Goh, 2011). Effective implementation of BIM processes should enable a shared digital representation founded on open standards for interoperability to be created, which can enable greater interrogation of the design helping to avoid wasted effort or duplication of work. The potential of BIM in its ultimate form is of a virtual information model to be handed from the design team to the contractor and subcontractors / supply chain and then to the client (Sebastian, 2011)

Early involvement in projects for contractors and key sub-contractors/supply chain members has long been advocated as best practice (Cain, 2003), Eastman, Teicholz, Sacks, & Liston (2011), agree and suggest IPD with joint contracts between designers, contractors and key sub-contractors best makes use of BIM, rather than the traditional fragmented approach.

Working with BIM increases the need for coordination, and management of design process and collaboration. Dawood & Iqbal, (2010) argue architectural practices have the opportunity to lead the adoption of BIM to support this integrated project delivery because it enhances control, coordination and management of building projects. Gilmore, (2011) stated he firmly believes that contractors have got to take charge and become the integrators; "we need to create the manufacturing model from all the design models that the designers generate". Both Paul Morrell and Sam Collard (Engineering leader of a leading UK contractor) in a BIM round table established that they believe that contractors are best placed to be the integrators (NBS, 2011), whilst Eynon, (2011) argues that as BIM is only a tool, which is operated by people that still need to produce the right information and inputs and complete their activities at the right time, therefore for BIM to be effective the contractors design manager as "orchestrator and facilitator of the integrated and coordinated design process" is ideally placed to ensure that this process effective occurs.

Regardless of the mechanics of how the process is implemented it is worth stating many of the perceived and reported benefits of implementing the process into working practices.

Key Benefits	Commentary
Integrated working	BIM not only enables integration, it virtually demands it. In order to realise the full potential of BIM, integration of the whole project team is required, the design team can hand the BIM to the contractor, who can share this information with the supply chain, and relevant specialist sub-contractors each adding their own experience and knowledge, and tracking the changes to the single model (Sebastian, 2011) .
Improved design coordination	Before even starting on site the building can be built digitally, "*Build it twice-solve the issues once*" (Gilmore, 2011). Clash detection has great benefits to contractors when all sub-contractors and fabricators use BIM (Eastman et el, 2011) coordination error checking is undertaken automatically highlighting any clashes that may well have occurred. The *cost of a clash* exercise undertaken by Handler (2006) demonstrated the potential cost occurring of $4932 resulting from a single PVC pipe clashing with a single steel beam owing to design error and subsequent rework, but as this was detected ahead of time with clash detection processes the actual costs were $2935.
Health and Safety planning	4D-Planning can result in improved planning of construction operations (Sulankivi, Makela, & Kiviniemi, 2009). Temporary works and safety management strategies can be incorporated into the model or animation to aid discussion through greater use of visualization.
Planning & costing efficiencies	Automatic generation of data (such as quantities) directly out of the BIM model in order to suit the activities undertaken by the construction planning, surveying or estimating teams.
Design For Manufacture and Assembly (DFMA)	3D modelling product data can be exploited and used for manufacturing products straight from the BIM. 4D programming in conjunction with lean construction strategies (e.g. just in time), can enable successful delivery (Eastman et al., 2011; NBS, 2011; SCRI, 2011).
Commercial advantages	Public work accounts for approximately 40% of the construction industries workload (*Government Construction Strategy*, 2011). One contractor estimated savings of £350k on one project in 6 months using BIM (Gilmore, 2011).
Adding Value	Fully integrated BIM model can be passed to client / end users for the management of the buildings project lifecycle with all asset information stored within. COBie is the vehicle for sharing the non-graphic data about the facilities, can act as a guided index to other documentation such as 2D, 3D models (Government Construction Client Group, 2011).

Table 1 – Summary of Key BIM implementation benefits

In addition to the above listed benefits, a recent survey by McGraw-Hill (2010), which targeted BIM users in Western Europe, highlighted the biggest business values in terms of productivity gains as being reductions in: errors and omissions in construction documents; cycle time of specific workflows; and rework. The respondents also identified the following BIM benefits as contributing the most value

Improved collective understanding of design intent (69% of respondents)

Improved overall project quality (62%)

Reduced conflicts during construction (59%)

Reduced changes during construction (56%)

Fast client approval cycles (44%)

Better cost control/predictability (43%)

Reduced number of Requests For Information (RFI's) (43%)

Also in this survey Western European BIM users identified the following as the highest-value project benefits:

Reduced conflicts during construction (70%)

Improved collective understanding of design intent (59%)

Reduced changes during construction (56%)

Adapted from: McGraw-Hill (2010)

Barriers to implementation.

Culture, legal and commercial implications, and lack of e-readiness within an organisation appear to be the most prominent barriers to BIM implementation. Bew and Underwood (2009) whose research has been so influential to the UK Government construction strategy, stated that for an organisation to implement BIM it must be realistic relative to that organisations current capabilities, they have identified the three important characteristics of people, process and technology as being potential barriers to the e-readiness level of an organization. Additional barriers identified during the literature review are presented in Table 2.

Barriers to implementation	Commentary
People barriers	The Associated General Contractors of America (AGC) discuss that the biggest barrier for many is lack of senior leadership of companies. The AGC also highlight legal fears, fear for change and fear of the unknown (AGC, 2009). Regardless of this, implementing BIM requires skills and power at all levels within an organisation. There must be buy in from management at all levels to facilitate implementation, with motivation, empowerment and change management. With skills comes the required training (Bew & Underwood, 2009).
Training costs	*"Lack of appropriately trained staff, rather than the technology itself, is still the current bottleneck for most companies"* (Eastman et al., 2011) With training comes additional cost.
Process barriers	These can be aided by the production of a BIM information delivery manual (IDM) or similar, which can provide the concept for describing, displaying information required in the design, construction and operation, and if available when needed will make the entire process run smoother (Bew & Underwood, 2009).
Technology barriers	Components include hardware (servers, clients, peers) and software solutions in order to progress BIM implementation in an organization (Bew & Underwood, 2009).
Commercial barriers	Sebastian, (2011) highlights with the vision of open neutral BIM, whilst acknowledging that conflicts of interest (e.g. knowledge sharing) and local constraints can't be avoided in Europe, and concludes that breaking through the business and legal barrier to improve large scale BIM implementation requires a radical change in the way processes of a building project are organised.
Legal & Contractual barriers, including copyright and ownership of the model	Greenwood, Lewis, & Lockley, (2010) highlight the legal barriers for BIM and collaborative working being risk allocation; copyright; insurance; ownership of a shared BIM design; schedules of deliverables; issues of who manages the modelling process, and the reliance placed on the modelled information. In conclusion they stress that standard forms of contracts in the UK have not yet been supplemented with BIM provisions.
Cultural barriers	Yan & Damian, (2008) researching the barriers to implementation of building information modelling concluding the largest latent barrier was that people do not want to learn BIM or think current technology is enough. Further research into this in the UK could identify a comparison now that the government have targeted fully collaborative BIM as a minimum by 2016 (Government Construction Strategy, 2011).

Table 2 – Summary of Key BIM implementation barriers

RESEARCH

The purpose of the research was to explore the experiences and perspectives of large and SME construction contractors regarding the implementation of BIM processes into their working practices. Quantitative research was undertaken by posting online surveys on targeted professional networking websites. 38 completed responses were received, and 8 responses were disqualified because the respondents did not work for a contracting organisation (i.e. consultancy/design firm etc). Therefore 30 responses were used in the final analysis and the statistical data arising from these responses was analysed using the SPSS computer software package.

23.3% of responses were received from employees working for Small contractors (0-49 employees) with 20% of respondents being employed by medium sized contractors (50-249 employees). For the purposes of analysing different perspectives of BIM implementation between large and SME construction contractors the researchers have grouped the responses given by the small and medium sized contracting organisations together as this gives a more comparable split of 43.3% SME's against the 56.1% of responses were received from employees working for large contractors (250+ employees).

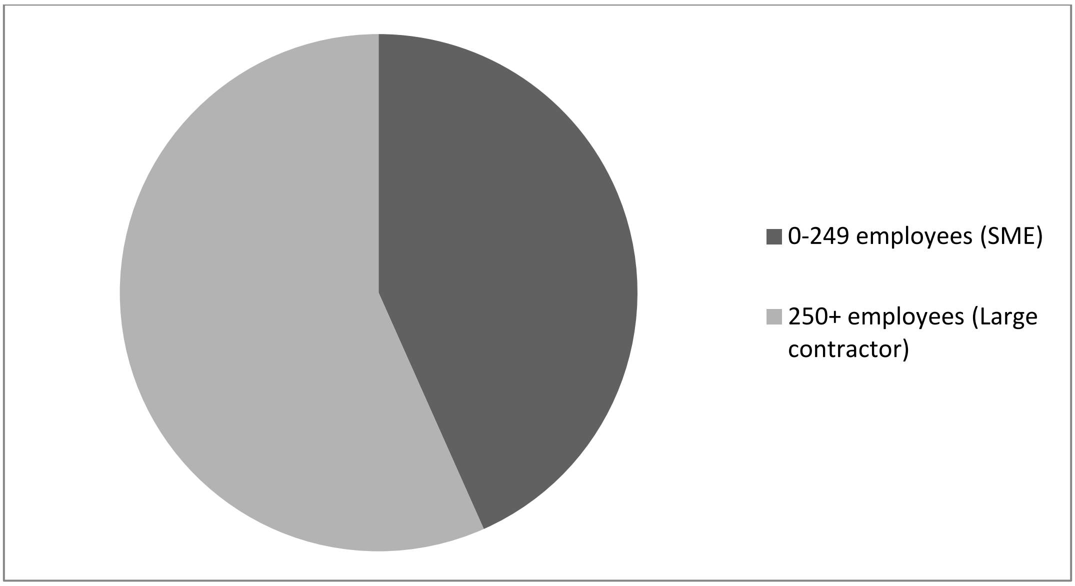

Figure 2: Split of large and SME construction organisations surveyed

Following initial questions ascertaining respondent demographics including professional profile and organisation size and function, research questions were posed regarding awareness, understanding and use of BIM; awareness of UK Government BIM strategy; current and future plans to implement BIM working processes; BIM maturity of organization worked for; issues relating to current and future design coordination procedures, and barriers, drivers and critical factors regarding BIM implementation in their organization. Some of the findings of this research are presented within this paper.

RESULTS

The respondents represent a mixture of disciplines working within contracting organisations including Design managers / coordinators (30%), Project managers (16.7%) Quantity surveyors (13.3%), Estimators (10%), Construction managers and M&E engineers (both 6.7%) the other disciplines included a construction planner, an architect working for a contractor, an engineer, a business development manager, a draughtsman and a sales manager. Of these disciplines 90% of respondents identified that they held management positions above middle management level.

The survey found that 20% of these respondents were not aware of BIM which is similar to the 21% of the construction population identified in the 2012 national BIM survey (NBS, 2012). Current BIM users in this survey were 6.7% as opposed to the 23% of contractors identified by McGraw-Hill, (2010). Of the remaining responses, 10% have plans to implement BIM with 16.7% building awareness for implementation and a further 46.7% or respondents aware of, but not currently planning for, the implementation of BIM in their working practices. These figures do contrast with the NBS 2012 National BIM Survey where the issue of current use and awareness across multiple disciplines was assessed as being 31% (NBS, 2012), in this study only 1 out of 13 (7.7%) of SME Contractors identified themselves as building awareness planning to implement BIM compared to 9 out of 17 (53%) of the larger contractors. Encouragingly 67.8% of respondents understand BIM as a process rather than those who understand BIM only as a software/technology.

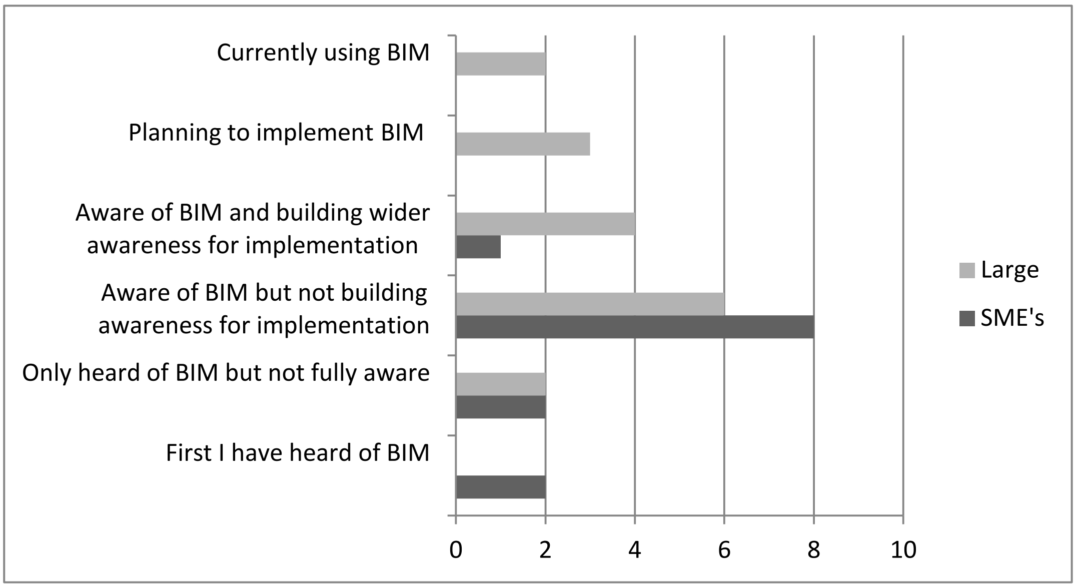

Figure 3: Awareness and use of BIM by contractor size

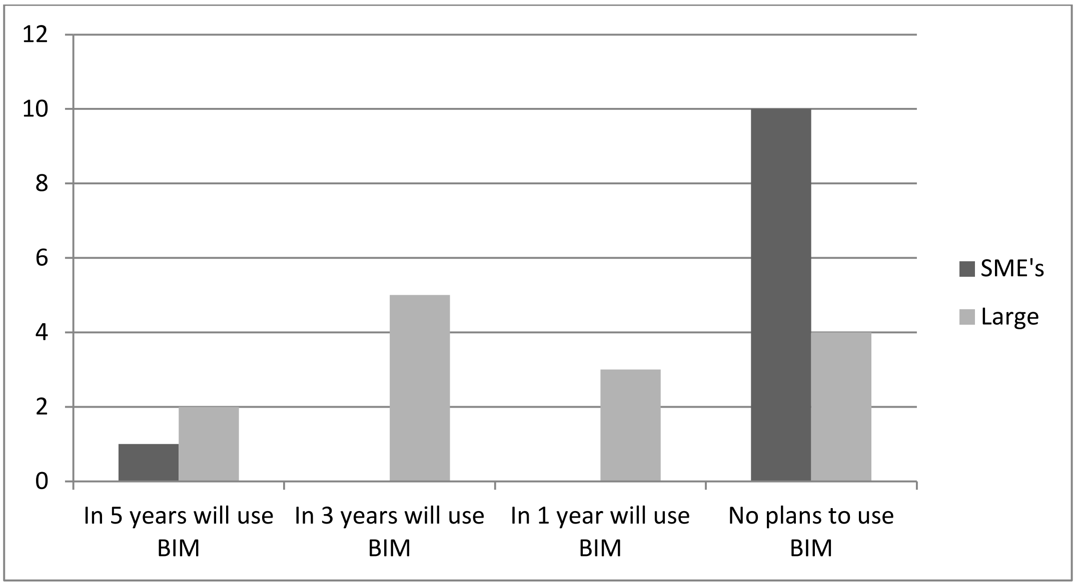

Figure 4: Plans to implement BIM by contractor size

In terms of client leading the change the results were that 70% of respondents have no experience of clients asking for the use of BIM, 13.3% have experienced it once whilst 16.67% have clients sometimes asking for the use of BIM. It was surprising that 32.14% of respondents were not aware that the UK Government has mandated the use of BIM on all public projects as a minimum by 2016. In terms of BIM readiness, 36.67% of the respondents’ organisations are currently working at phase 0 of the UK Government’s evolution model for BIM and 53.33% at phase 1 BIM. 6.7% are currently working at phase 2 with one respondent stating they are working at fully collaborative BIM working processes and technologies (3.3%)

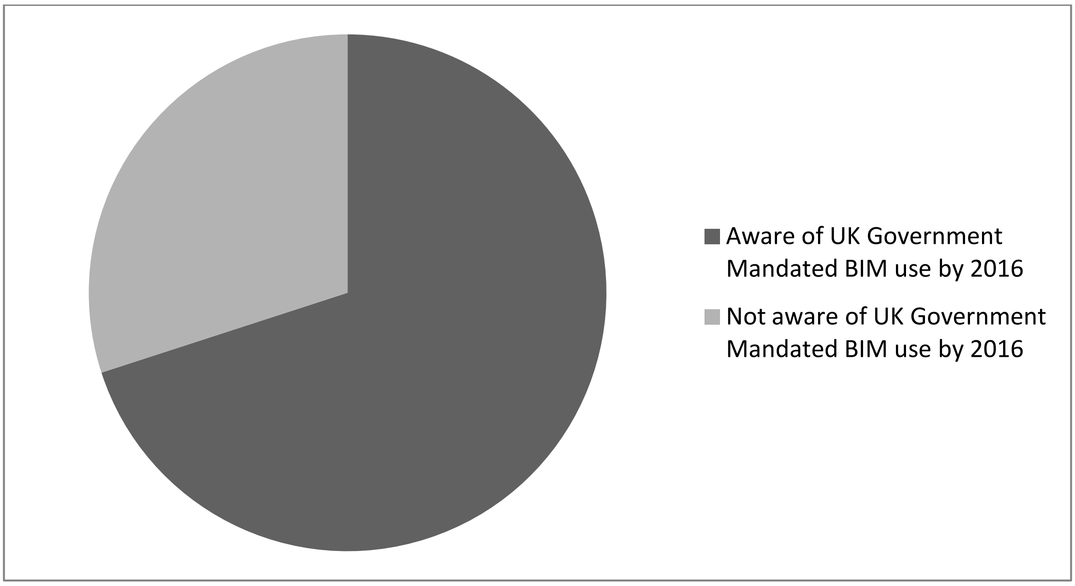

Figure 5: Awareness of UK Government 2016 mandate across all respondents

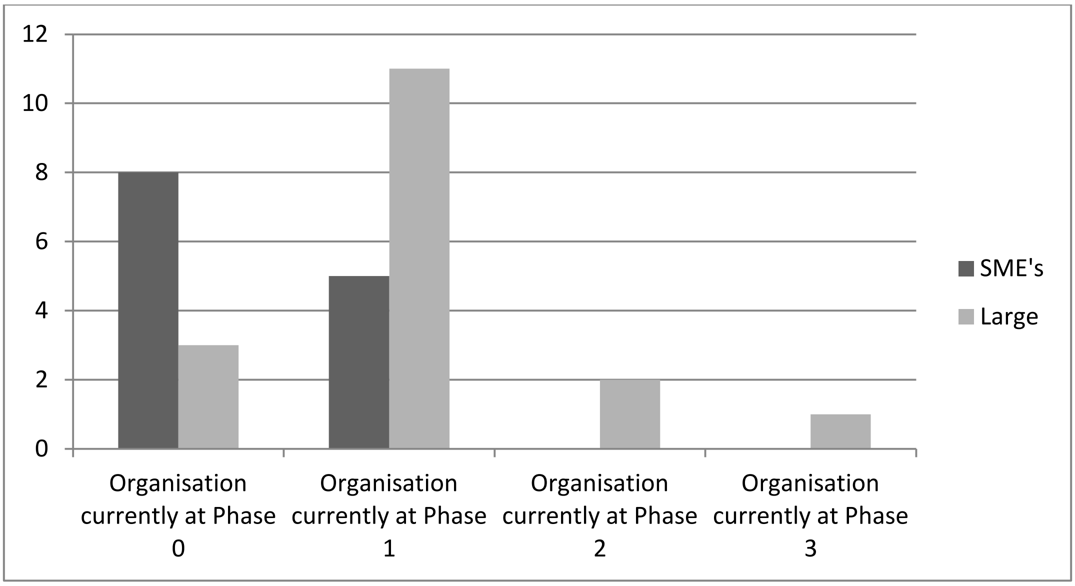

Figure 6: BIM maturity by contractor size

The Contractors were grouped by size in order to make comparisons between the experiences and perspectives of SME and large contractors regarding implementing BIM working practices into their organisations in order to see what the similarities were and discover any significant differences between the two groups.

The research confirmed differences between contractor size, awareness and plans to implement BIM with the larger companies having greater awareness and greater planning for implementation. Respondents confirmed that client demand for BIM has been low with 70% of respondents having no experience of clients asking for BIM. In terms of BIM Maturity only 10% of the organisations represented currently consider themselves e-ready to deliver the solutions as required by the UK Government BIM strategy with 62.5% of respondents who provide design services still producing 2D CAD drawings only.

The results highlighted an agreement between the groups' respondents that the biggest barrier to implementation was the associated costs issues with a high level of concern that clients will not pay extra for the use of BIM closely followed by the expenditure involved in the people, process and technology changes involved in an organization becoming e-ready.

Both groups recognized improved design coordination including utilizing the benefit of clash detection software and increased collaboration as the main benefits of BIM. The respondents also identified other benefits such as further cost savings enabled through issues such as automated quantification, and improved efficiencies such as reducing or avoiding unnecessary duplication of effort. Critical factors / actions identified by the respondents to enable BIM implementation was the possibility of financial support from the government, with SME organisations in particular highlighting a lack of profit or inadequate revenue to invest in new processes and technologies due to significantly lower profit margins because of economic market conditions.

CONCLUSIONS

It can be seen that the perspectives of SME contractors and large contractors are mostly parallel; however there is significant difference in opinion concerned with the legal barriers towards the implementation of BIM between contractor sizes highlighting the need for further investigation. It was the view of some SME contracting organisations that timescales allocated to them in typical contractual procurement processes would not afford enough time for BIM processes to be successfully implemented into their working practice. There was also a significant difference in opinion between the groups that the cost and time savings would be passed down to the supply chain from the larger contractors to the benefit of both groups, with the belief from some of the SME organisations that this would ultimately lead to a reduced income levels.

It would be easy to dismiss some of the more negative views of the responses given by the SME respondents as a fear of the unknown, but the authors draw attention to the fact that the respondents employed by large contracting organisations who primarily fulfil one main functional role within their organization (estimating, M&E engineer etc.), may not appreciate the full range of concerns that someone working for a SME, who may have a broader range of roles and responsibilities will hold.

Future research

A follow up longitudinal study is planned by the research team aiming to give further insight into opinions awareness and attitudes towards BIM by large and SME contractors as it matures in the UK construction industry.

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