BIM ARTICULATION IN DIFFERENT-SIZED ARCHITECTURAL FIRMS

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The empirical domain of research into the implementation of Building Information Modelling (BIM) has tended to be large architectural practices working on mega projects. The majority of construction projects that use BIM (including mega projects) involve small- and medium-sized architectural firms. An understanding of how the commonalities and differences that different-sized architectural firms articulate and implement BIM, and how BIM practices are integrated across the supply chain that may consist of large and small firms, is essential if sector-wide reform is to take place. Research has been conducted that explores the distinctive nature of innovation in small construction firms, but less research articulates how BIM is played out, in the settings of large and smaller architectural firms. Results are given from case study enquiries of eleven different-sized architectural firms that use BIM. This research contributes to the understandings of the different contexts of large and smaller practices. Certain differences were identified amongst the different-sized firms, in terms of the way practitioners perceived BIM. Smaller firms mainly reflected the technical stance of BIM while more practitioners in the large firms expressed the practice-based approach in describing BIM.

Keywords: BIM, implementation, articulation, different-sized architectural firms

INTRODUCTION

This research is concerned with developing an understanding of how different-sized architectural practices articulate and implement Building Information Modelling (BIM). BIM involves using advanced technologies for creating as well as operating data, in addition to standards and repositories for storing and accessing data, by different stakeholders across various organizations. There is a range of current policy drivers that aim to improve the delivery of the built environment through BIM. In the UK, for example, the BIM process is envisioned to improve the delivery of the built environment (BIM Task Group, 2011) by having a fully collaborative 3D BIM, with electronic asset information and documentation (Cabinet Office, 2011). BIM is proposed as a collaborative way of building, construction management, cost control, decision making and information exchange. All those involved in a development from conception through to completion should work to the same standard, allow access to information, and integrate various design aspects to detect conflicts and reduce mistakes. There seems to be no consensus in the extensive literature that has discussed BIM about the definition of the term. BIM is used differently by various collaborators, so there is a wide range of views of BIM. BIM has been described as 'a new approach to design, construction, and facility management' (Eastman *et al*., 2008, vii) that targets various inefficiencies in

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construction practices including cost, project duration and interoperability of data. With BIM technologies, a virtual building is constructed with attached data required to support many activities across the lifecycle of a building (Eastman *et al*., 2008). What differentiates BIM is the ability to create digital, shared, integrated and interoperable models rather than a disconnected collection of diagrams, drawings, models and specifications (Kymmell 2008). To improve visualization and eliminate conflicts, waste and risk, the building project and the construction process are simulated in a virtual environment (Kymmell 2008). Additionally, various kinds of information can be linked to the BIM file, including specifications, contracts, operation and maintenance manuals, analysis reports and simulation (Hardin 2009). A variety of technologies and processes used along with other related project management tools are considered to be BIM. BIM technologies include parametric three dimensional computer-aided design (CAD) technologies, three spatial dimensions with time and cost components, and Geographic Information Systems (GIS). Shared standards, databases and repositories, document management processes, and IT-based collaboration platforms are also becoming associated with BIM. In fact the concept, approaches and methodologies identified as BIM have been around for years (Eastman *et al*., 2008), but became recently injected as BIM agenda discourse, and therefore attracted professional and industry awareness.

Various debates concerning BIM as well as large, small- and medium-sized firms are summarized in the next sections to clarify the problem statement and specify the research question. The research design and methods explain the research setting and how the empirical work was conducted in terms of data collection and analysis techniques. Then the findings provide interpretations of the data to relate the analysis to the broad themes identified in the pertinent literature such as the plurality of the term BIM, technical stances, and practice-based approaches. Sorting out various perspectives of BIM and linking the literature with empirical material in the analysis section, contributes to the understandings of how BIM was implemented and articulated in different-sized architectural practices. Finally the discussion and conclusions reflect on the research question and highlight the implications of the study, as well as new directions for research.

VARIOUS PERSPECTIVES OF BIM

The term Building Information Modelling (BIM) was introduced to the construction management industry in the early 2000s (Garber, 2009). BIM has been defined in various ways; one example is ‘a managed approach to the collection and exploitation of information across a project. At the heart is a computer-generated model containing all graphical and tabular information about the design, construction and operation of the asset’ (BIM Task Group, 2011, 91). Succar (2010) talked about the multi-dimensional nature of the BIM domain as a combination of policies, processes and technologies. The technological aspects of BIM were the focus of many definitions (e.g. Rezgui *et al*., 2009); however, BIM is not only limited to certain tools and technologies but to the interoperable information exchanges and business structures practices too (Garber, 2009). BIM is used to refer to an activity, tools, processes and technologies used to plan and manage construction projects (Eastman *et al*., 2008, Demian and Walters, 2013), through the life-cycle of assets (e.g. Shetty *et al*., 2013) from inception and design to demolition and recycling.

Several definitions of BIM refer to parts of the overall process (Coates *et al*., 2010), as a number of participants are involved at different stages of the life cycle of projects and have different motivations to adopt BIM. Owners and facility managers are interested in

cost and asset management while architects can be motivated by the capabilities of 3D modelling in producing consistent drawings and eliminating spatial conflicts (Eastman *et al*., 2008). Engineers focus on the performance of buildings, sustainability consultants can measure day lighting and solar orientation (Hardin 2009), and contractors can push for earlier involvement in construction projects. The increased number of participants involved in the overall BIM process created tensions between these different perspectives, and contributed to the confusion of what constitutes BIM. The plurality of BIM definitions suggests that there is no single way of describing what constitutes BIM but instead, generic characteristics commonly associated with BIM can be used to describe the term. BIM has been viewed from various strands of thought that can be grouped into three main perspectives: policy outlooks, technical stances, and practice-based approaches. Possible tensions can be identified amongst the normative BIM literature, i.e. the UK government construction strategy on BIM, and the descriptive BIM literature that is based on empirical evidence. Proponents of BIM promote the possible benefits and have high anticipations in terms of value, cost and carbon improvement (e.g. Rezgui, Zarli and Hopfe 2009, BIM Task Group 2011). On the other hand, there are opponents who are still unconvinced by the purported advantages of BIM, as there is not enough empirical evidence to support them yet.

There seems to be a substantial amount of heterogeneity regarding how to describe BIM. Additionally the existing research on BIM often presumes that architectural practices are similar and privileges large firms, despite the sizable proportion of smaller firms that are currently underrepresented. The majority of construction projects that use BIM (including mega projects) involve small- and medium-sized firms. An understanding of how the commonalities and differences that different-sized design practices articulate and implement BIM, and how BIM practices are integrated across the supply chain that may consist of large and small firms, is essential if sector-wide reform is to take place.

BIM in different-sized practices

There appears to be a significant amount of empirical research on BIM which favours large practices working on mega projects (e.g. Taylor and Bernstein, 2009, Davies and Harty, 2013), as it is often argued that BIM has little benefit for small- and medium-sized firms (Arayici *et al*., 2011, Leeuwis *et al*., 2013). There is a wide range of design and construction firms varying from large companies that provide various services and work in many countries to smaller companies that usually work on small projects and offer particular services like housing projects (Symes *et al*., 1995). Different ways of measuring firm size (for example, architectural firms) can be used according to the number of architects, the number of design-related professionals, the number of all professionals or the total number of billings (Symes *et al*., 1995). Given that architects increasingly work as part of a team of various professionals, engineers, planners, landscape architects, interior designers and surveyors (Symes *et al*., 1995), firms are examined in this study using a three-way split depending on the number of all professionals: firms with 1-30 staff are considered small, firms with 31-50 staff are medium and firms with over 50 staff are large.

Some of the small- and medium-sized firms are beginning to use BIM; however, there is little understanding of how BIM is perceived by the practitioners in this sector. Previous research has examined professionals' accounts of their work in architecture (e.g. Cohen *et al*., 2005, Sturges, 2013) but tended to consider leading firms only (Sturges, 2013), as if they are exemplars of architectural practices. Cohen (2005) attempted to cover a wide range of architectural practices by studying non-professional organizations such as local

authorities, a building contractor, a property developer as well as architect practices, the Royal Institute of British Architects (RIBA) and a school of architecture. However, Cohen *et al*., (2005) did not make a distinction between the nine architectural practices they studied. In fact architectural practices are not uniform and the difference between large and smaller firms needs further attention.

A large number of architects work in small- and medium-sized practices: according to a report of the Architect's Council of Europe (ACE) (ACE, 2012) less than 1% of architectural practices have 31 or more architectural staff. The survey in this report covered 95% of the profession in Europe and revealed that a noticeable majority (63%) are practices that have one person only, 18% have two people while 15% employ 3-5 staff. In the UK, for example, out of 6385 architectural practices, there are only 65 architectural practices with 31 to 50 staff and 16 practices with over 50 staff (ACE, 2012). This sector study revealed that the profession of architecture continues to undergo economic crisis; as a result large practices made cuts in their staffing, which in turn increased 'micro' practices set up by redundant architects (ACE, 2012).

Small architectural firms are found to operate in different ways in comparison with larger firms and have a unique complex behavioural and organizational context (Lu and Sexton, 2009). In fact, the study by ACE (2012) mostly compared results across countries but also showed some differences between small and larger architectural practices. One example is that larger practices appear to show more optimism than smaller ones, as fewer than 20% of large firms (with 30 or more staff) expected workload to fall in the next year in comparison with about 40% of smaller practices (with five or fewer staff) (ACE, 2012). Small professional service firms in the built environment are not only vital to the success of the design, construction and property industries but also to their long-term viability (Lu and Sexton, 2009).

Despite the substantial proportion of small architectural firms, most studies focus on large international firms, as they are generally considered to be the frontrunners in the application of BIM, as one example. Only little research is beginning to consider small architectural firms, who are located in a distinctive business environment compared with other sorts of industry firms (e.g. Leeuwis *et al*., 2013, Lu and Sexton, 2006). Leeuwis *et al*., (2013) unravelled the uptake of BIM use in small architectural firms in The Netherlands and found that their use of BIM is mostly restricted to internal processes only. One possible explanation for this limited use of BIM in small architectural firms is due to the lack of experience within these firms, as well as among their clients and other participants they work with (Leeuwis *et al*., 2013).

Summary and research question

The research problem is defined from two key issues. First, the ambitious push from policy drivers stressing that BIM is the way forward but at the same time, there is still ambiguity regarding what BIM actually involves. Second, the fact that the empirical domain of research into the implementation of BIM has tended to focus on large practices working on mega projects. Thus the research question aims to explore the commonalities and differences of how BIM is articulated and implemented within the context of different-sized architectural firms.

RESEARCH DESIGN AND METHODS

The empirical material discussed in this paper represents one aspect (that of commonalities and differences of BIM implementation and articulation in different-sized firms) of a larger research project exploring BIM-enabled projects in architectural

practices in the UK and USA. The overall approach to research that has been taken in this study is focused on interpretations of qualitative data. Adopting a qualitative approach in this research enabled exploring BIM articulation as 'lived experience' based on the accounts of BIM practitioners, which is similar to earlier studies (e.g. Caven and Diop, 2012). Caven and Diop (2012) explored a career in architecture and based their findings on the accounts of architects in the UK and France within an interpretive paradigm.

The interpretive approach enables forming rich understandings of meanings (Silverman, 2006), it allows exploring how BIM is articulated and assists in identifying the main characteristics associated with BIM within different-sized architectural practices.

Research setting

The setting for this study is eleven different sized firms which envision themselves as leaders in architectural services. Firms in this study are identified by numbers from 1-5 if they are considered large and employ over 50 staff. Each one of these large firms has offices worldwide and at least one office in both the UK and USA, their employees range from 950 to 3500 in a range of offices (13-44) worldwide. Firms with 31-50 staff are considered medium, while firms with 1-30 staff are described as small. Small and medium sized firms are grouped together and described by letters A-F. All firms have a focus on architecture amongst other specialities, including engineering, planning and consultancy. The firms have been selected because of their engagement with BIM but varied in their experience. The research methods used in this study for collecting and analysing data are explained below.

Data collection

Data for this research were mainly collected using open-ended questions in semi-structured interviews. Although the interviews involved the same general questions, there was flexibility for exploring areas of special expertise to each interviewee in depth (Isabella, 1990). For example, some interviewees gave more details about the technical aspect of BIM they are involved in, while more senior participants or regional managers talked about BIM from a strategic level. Most interviews were one to one but all together 39 interviews were conducted with 49 practitioners, as some participants came together to certain interviews. Interviews were conducted in 18 regional offices of architectural practices based in Houston, Dallas, San Francisco and London. Following desk-based research to gather background information and understand the scope of BIM projects within these firms, the firms were contacted through academic colleagues in the UK and USA. The firms were asked to identify professionals involved in BIM projects in 2-3 offices in the USA and UK. Some of the interviewees also helped broker access to other firms or regional offices of their firm. Additional complementary materials including 452 pages of documents, 69 slides and 10 hours of observations were also collected to help understand the context and interpret the interview data.

Data analysis

Thematic coding was used to analyse the interview data; this technique indicates themes emerging from the data. In this interpretive approach, researchers make sense of the data and develop themes about their meanings (Creswell, 2003), through a messy iterative process or dialogue between empirical data or evidence and theoretical constructs extracted from the literature (Orton, 1997, Eisenhardt, 1989). One example of this iterative process is the comparison of how BIM is interpreted by BIM practitioners against how it is described in the literature. All the interviews were transcribed verbatim, and then checked against the audio files for consistency and correctness before starting to

code the data. This also helped in the familiarization process of the whole dataset, and served as a further step of giving an overview of the data prior to coding. Qualitative analysis software, NVivo, was used to help organize and identify abstract key themes from the interview transcripts. Other complementary materials collected were referred to frequently to help understand the context.

Initially, data were analysed in NVivo in a preliminary manner using topic coding, in which segments of data concerning specific topics were grouped together for additional analysis. Then a process of unpacking the general topics and preliminary descriptive codes (Charmaz, 2006, Andrade, 2009) created additional focused codes (Andrade, 2009). One example of this topic coding is the BIM definition generic code, which was later unpacked. The coding schema was finessed over 12 months of work, going through three main iterations of coding.

FINDINGS

Plurality of BIM

Within large and smaller firms, the participants found it challenging to articulate BIM, and their descriptions were generally split between the technical or practice-based focus. The participants were asked to define BIM as an introductory question in the interview. It was surprising to some interviewees to be asked this question. An Information Systems Application Administrator "at Firm 5 (London)" seemed unsure and said: 'How do I define BIM? It's a good question. (Laughter) It's a good question. I don't think there is an easy definition.' The interviewees in the beginning were not sure how to define BIM, and then came up with an answer of how they perceived BIM. One of the reasons for this difficulty in describing BIM was that the term BIM covers a wide range of things, as the interviewees articulated. An Associate and BIM Manager "at Firm D (London)" commented: 'I bet everyone laughs when you ask them that. For me BIM is a hugely broad topic and it covers so many things.' Additionally people perceive BIM differently, a Director of Technical Development "at Firm 4 (London)" stated: 'How I define BIM and how other people see it is different.' Practitioners articulate BIM in a different way even in the same office, depending on their experience and involvement in the BIM process, as this participant noted:

> If you talk to two of our studios, like if you talk to our architecture studio upstairs or if you talk to the studio you just walked through, they would have two different answers, Regional BIM Manager at Firm 1 (Houston)

BIM was defined in many different ways; twelve different codes emerged in NVivo under the BIM definition including information management, collaborative work across disciplines, new ways of working and a work process as examples of popular codes across the data set. This plurality of BIM was consistently reflected in the data:

> BIM is, it's a tough one to define… I think that too many people think of it as just software…the way I would describe it, it's virtually constructing our projects with integrated systems that allow information integration and connectivity...But it's also a process in that it's shaping the way we integrate and collaborate with other consultants, Associate and Digital Design Leader at Firm 1 (London)

In general, BIM definitions conveyed by the interviewees, in different-sized architectural practices are diverse but were grouped under either the technical which were mostly represented in the smaller firms or practice-based perspectives which were more evident in the large firms. The following two subsections elaborate on the technical and practice-based focus of BIM.

Technical focus of BIM in the smaller firms

For a large number of participants, mostly in the smaller firms, the term BIM is communicated as software only. For those who are aware of the broader processes and practices of BIM, the focus is still on object-oriented approaches to modelling within advanced CAD packages such as Revit:

> Well for us, we've got a bias towards the three dimensional nature of it, Architect at Firm C (London)

Revit is a totally distinct package from Auto CAD. Revit is a group of integrated products that includes Revit Architecture, Revit Structure, and Revit MEP. Revit architecture is one of the well-known products for using BIM in architectural design. Revit also facilitates energy simulation and load analysis, structural analysis and includes the ability to import models from Sketchup, a conceptual design tool, as well as other systems. This focus on the technical aspect of BIM within the overall broad idea was evident in the smaller firms. Only some interviewees from the larger firms noted that most of their knowledge is mainly limited to Revit, and that was the meaning of BIM to them:

> I think of it just in terms of the one program since that's the one we mostly use. The term has been around for a while but I didn't have a lot of experience or knowledge of it before we started using Revit. So I'd say most of my knowledge about BIM is related to Revit, Project Architect and Project Manager at Firm 1 (Houston)

Many interviewees formed their description of BIM around the software packages involved, and the modelling and analytic aspect of BIM. One of the technical-focused definitions of BIM in the smaller firms was mainly around inputting and connecting information in the model as a basic concept of BIM:

> Building as a verb or building as a noun. People say modelling or management or managing and to be perfectly honest it doesn't matter. All we're trained to do is to connect the information so each piece of information exists once… And that's the very, very simplest low level of concept of BIM I can manage, BIM Manager at Firm B (London)

Most of the participants from the smaller firms expressed the technical stance of BIM. The experience of the interviewees and in some cases the perspective of BIM was restricted to the technical stance within the general broader idea of BIM.

Practice-based focus of BIM in the large firms

The practitioners who expressed their perception of BIM from a practice-based approach were largely in the large firms. In the large firms, the interviewees confirmed that BIM is not just about software. Rather BIM is about work processes and collaborations using different tools and technologies:

> It does not describe a tool, it does not describe Revit, it describes the process … so when we say BIM it could be Archicad or even AutoCAD, 3D and all of these different things, BIM Manager at Firm 2 (Houston)

The participants also expressed that BIM involves work processes and people. The primary focus of a BIM process is about information management to create a good project. The secondary purpose is to facilitate the coordination of the input of different consultants to meet the needs of clients:

> How do I define BIM? Okay it's to me? What does it mean to me? It's a process to me of compiling and organising information that will help our team design a great project… that's primary, and the secondary would be to help with the co-ordination efforts of various consultants and the client's needs, Associate, Design and Technical Abilities at Firm 5 (Dallas)

In the same way in the smaller firms, some participants talked about how BIM changed their work processes to make it more efficient, when they defined BIM:

> It's change of every little piece of what we do, to streamline and make the whole process more efficient', Associate Director at Firm F (London)

However more participants from the larger firms conveyed the practice-based approach. Taken as a whole, there is no agreed definition as to what BIM actually meant in different-sized architectural firms. Yet the different organizational contexts in large and smaller firms influenced the individual interpretations of BIM in most cases. BIM practitioners defined the term BIM differently according to their experience of BIM projects in the firm; nonetheless, certain characteristics were commonly associated with BIM.

DISCUSSION AND CONCLUSIONS

This research focused on five large USA and UK architectural firms, and a follow-up sample of six small- to medium-sized firms using BIM. The case study findings shed light on how BIM was perceived by practitioners in different-sized firms. The BIM definitions articulated by the practitioners showed the plurality of the term BIM, and the different perspectives taken in architectural practices to describe it, such as the technical focus and practice-based focus. In the technical focus, BIM definitions were limited to certain tools and technologies while in the practice-based focus, the work process was considered as well as the people and software packages involved.

The plurality of BIM, identified in the case study findings, was consistent with the literature reviewed earlier (e.g. Succar (2010) who talked about the multi-dimensional nature of the BIM domain. The accounts of BIM practitioners confirmed the different perspectives of the BIM construct. The UK government policy outlook (BIM Task Group, 2011) was also reflected in BIM practitioners' accounts as a driver for BIM implementation in the UK, particularly in the smaller firms. Technical stances on BIM (e.g. Rezgui *et al*., 2009) dominated the way BIM was described in both large and smaller firms, while other participants, mainly in the large firms, took the practice-based approach (e.g. Davies and Harty, 2013) to describe BIM. The findings contributed to extending our understandings of how different-sized architectural practices interpreted BIM-enabled projects.

The research extends our knowledge of how large and smaller interdisciplinary architectural firms were using BIM, unlike the majority of earlier research, which favoured large firms working on mega projects (e.g. Taylor and Bernstein, 2009, Davies and Harty, 2013). The responses collected from the large firms were also mostly evident in the smaller firms. However, the findings did identify certain differences between large and smaller interdisciplinary architectural firms, in terms of the way practitioners perceived BIM. One example is that the smaller firms mainly reflected the technical stance of BIM, while more participants in the large firms expressed the practice-based approach in describing BIM. Another example is that those participants who found it hard to define BIM were in the large rather than smaller firms. The unique nature of smaller firms is consistent with the emerging literature that articulated the distinctiveness of small firms (e.g. Lu and Sexton, 2006, ACE, 2012). Unlike what former research on BIM use in small architectural firms found (Leeuwis *et al*., 2013), BIM use was not restricted to internal use only in small firms, as the broader process of BIM also had value to smaller firms.

The results of the research are restricted by the extent of representativeness and generalizability of the selected firms. These limitations were taken into consideration by a careful sampling strategy to choose representative firms. In addition, BIM descriptions given are implicitly related to industry rhetoric and policy definitions. The empirically-based definitions of BIM presented in this study are dependent on the interpretations of interviewees, how they themselves understood and used BIM, and the research project information given to them prior to the interview. In addition the research was conducted at a certain point in time and the perception of BIM might change over time given the fast development of BIM adoption. It would also be of interest to contrast or confirm BIM practitioners' accounts by non-BIM users in future research or over a long period of time.

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