UNDERSTANDING THE POLARIZED PERSPECTIVES IN BIM ENABLED PROJECTS

Mustafa Selcuk Cidik[1], David Boyd and Niraj Thurairajah

[1] Birmingham School of the Built Environment, Birmingham City University, Birmingham B4 7XG, UK

Successful implementation and use of Building Information Modelling (BIM) require consideration of people issues. Two polarised views of BIM are shown from the literature based on technology-centred or human-centred perspectives each of which acknowledges the other but subsumes this into their view. Indeed it is the way that each adopts the other that is problematic. This paper demonstrates that acknowledging these differences and working with them better addresses the management of the implementation of BIM. Empirical findings, from in-depth interviews in a multi-disciplinary engineering company, show that individuals use BIM but are confused by its role depending on their job and perspective. Given this, collaboration and development are held back by the un-expressed differences. It is argued that recognising these differences and using them in a balanced way is essential for the successful adoption of BIM.

Keywords: BIM, human-centred, technology-centred, implementation, development

INTRODUCTION

Building Information Modelling (BIM) has become a significant topic for the UK construction industry due to the UK government's decree (UK Cabinet Office 2012), promotion of its potential benefits (e.g. Azhar 2011) and expectations of consequent business improvement (e.g. Gu et al. 2008). However, despite these push factors, it has been argued internationally, that the BIM adoption rate is slower than anticipated (Azhar 2011; Gu et al. 2008; Gu & London 2010) and its full potential has not been realized where it is implemented (Brewer & Gajendran 2012).

It is stated that in addition to technology implementation, BIM implementation should include process and organizational changes in order to realize its potential benefits and these changes should consider people issues (Gu & London 2010; Arayici et al. 2011; Olatunji 2011). Furthermore, it has been argued that the inability to realize the full potential of BIM is connected to people issues (Neff et al. 2010; Brewer & Gajendran 2012). In a similar way, Hartmann et al. (2012) criticize the top-down, technology-push approach that dominates the BIM implementation literature. Here, the top-down, technology-push approach suggests that business processes need to be aligned to a new way of working that BIM requires to realize its benefits. Their argument does not mean that the majority of existing work does not pay attention to people issues but

[1] Mustafa.cidik@mail.bcu.ac.uk

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rather suggests that their starting position for problem statement and problem resolution is more technology-centred.

This paper picks up this last point and uses it to consider the different views of BIM between objectivist/technology-centred perspectives and constructivist/human-centred perspectives. The paper adopts a human-centred perspective to counter the dominance of the technology-centred view (Hartmann et al. 2012) and argues for a more balanced view of BIM for positive change. Literature is presented which demonstrates extremes of views to clearly show their fundamental differences. It is argued that the polarization is set by the problem formulator's view of the connections between technology, organizations and people. According to the view they adopt, authors can see technological issues from human-centred perspective, or people issues with a technology-centred perspective. Thus, it is the way that each addresses the other that is problematic. Empirical evidence from interviews in a multi-disciplinary engineering practice shows that individuals are confused by their use of BIM because of the dominant technology-centred perspective overlooks some important issues that can be addressed with a human-centred perspective. It is argued that this makes collaboration difficult and successful development of BIM impossible. It is concluded that recognising these differences in perspective is essential so that a better understanding of the management issues can be achieved which would lead to effective solutions for the advancement of BIM.

The paper takes a critical realist position (Ackroyd & Fleetwood 2000; Mingers 2008) as being the most suitable for the practical task of researching how to use BIM better. This sees the physical world and technology as factually real but accepts that human views and actions of this are socially constructed. Key to a robust enquiry is to adopt a wide critical perspective on both ideas and practice.

LITERATURE

Information Technology (IT) perspectives

By its nature, the IT world is dominated by a technology view of problems. UK Government's BIM Industry Working Group (2011) also uses this view to identify “exploitable information” as the key driver to produce improvement. Objectification of the word 'information' assumes that the same information has the same meaning for different actors using it (BSI 2007; Mutis & Issa 2012). This view of information directly affects how problems in the world are viewed by reducing them to structured and objective information problems (Gleick 2011). Although definitions of information have been well discussed; the way these definitions are used depends on the view adopted for its conceptualization. Thus, the engineering system centred view sees technology as the driver of change and that people are subsumed into the technology.

The shortcoming was realized in 1980s and continues to be discussed (e.g. Wilson 2000; Theng & Sin 2012). Dervin and Nilan (1986) called for a paradigm shift in information needs and uses area away from a system centred view (that they call traditional view) to a user centred view (that they call alternative view). According to Dervin and Nilan (1986), the traditional view sees information as objective and as something to be transmitted in quantified packages from the system to users, where users are seen as input-output processors of information. This perspective focuses on externally observable dimensions of behaviour and events to search for propositions that are valid for different situations so emphasising the 'what' of systems.

In contrast, Dervin and Nilan's (1986) alternative view, posits information as something constructed by its users, human beings. Human beings are constantly freely constructing information (within system constraints) in relation to the system and the situational context; and therefore search for universal dimensions of sense-making thus emphasising the 'how' of systems.

Organizational perspectives

In a similar way to information, organizations can be viewed as machines or as social enterprises. BIM related studies (e.g. Gu & London 2010; Arayici et al. 2011) tend to see organizations as process systems which respond to the changing external environment (Lindsay et al. 2003). These systems can be seen as technology or human driven and this determines the approach to how business processes are modelled.

The technology-centred perspective of business process modelling adopts a simplistic view consisting of general input-process-output streams with clear start and end points. It has been argued that this approach is most suitable for production-line like, standardizable and automatable business processes (Lindsay et al. 2003). Many authors emphasize the difference of nature between production processes and goal-oriented processes in terms of process modelling (e.g. Lindsay et al. 2003; Kueng 2005). They claim that the analysis of activities which is done to model production processes is not appropriate to model office workflow, coordination processes and decision-making processes or, in other words, goal-oriented processes. Thus, the deterministic view is criticised for overlooking many hard-to-model important aspects of real life business practices (Melao & Pidd 2000; Lindsay et al. 2003). The human-centred perspective of process modelling some of which are listed in Table 1 accommodates these aspects.

Table 1: Different Techniques of Human-Centred Process Modelling

Author (Year)	Brief Explanation
Yu (1995)	i star Framework: A process modelling framework considering strategic dependencies of agents and issues and the concerns that agents have about existing processes and proposed alternatives.
Van Der Aalst (2012)	Process Mining: Analysis of collected event logs of activities in the processes for process discovery, monitoring and improvement. This technique has also been used for organizational perspectives and decision points analyses.
Dustdar et al. (2005)	Ad-hoc Process Mining: In this study authors aimed to explore ad-hoc processes which are described as “completely unstructured processes” using process mining.
Xia & Wei (2008)	A context driven business process adaptation approach in which business process context can be gathered and reasoned to modify business process structure.
Stoitsev et al. (2007)	A conceptual framework for unobtrusive support of unstructured, knowledge-intensive business processes.
Koschmider et al. (2010)	Social Software for Process Modelling: Use of social networks to help users to behave as modellers. Users are guided within the context of an existing Recommendation-Based BPM Support System to which social features are added.
Chan & Choi (1997)	Soft systems Methodology (SSM) is applied in Business Process Reengineering.

Melao and Pidd (2000) overview process modelling and relate different approaches to the philosophical stand points shown in Figure 1; for example, most of the techniques listed in Table 1 fall to the right half. The human-centred process modelling shows that deterministic modelling limits business practices and fails to assist innovation and creative improvisation (Brown & Duguid 2000). Lee (2005) argues for achieving a balance between business process optimization through modelling and the use of human-centred and human-driven business practices.

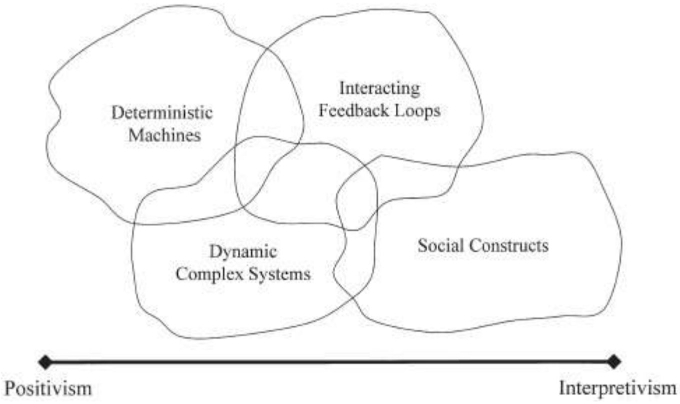

Figure 1: Business Process Views against Paradigms (Melao & Pidd 2000)

People perspectives

Although people perspectives tend to adopt a human-centred view, many authors writing about IT see people as machines (Brown & Duguid 2000, Brewer & Gajendran 2012). People live and work within organizational social settings and this leads to an explanation of behaviour set by organizational cultures. This is a disputed concept (Wright 1994) but can be taken as an explanation of how people within organizations create, shape and are affected by shared cognitive, affective and behavioural patterns. The centrality of organizational culture to organizational life is emphasised by several authors (e.g. Smircich 1983; Alvesson 2002).

Smircich's (1983) work focuses on two extreme views of organizational culture: functional and non-functional, which provides the argument for the differences adopted in this paper. The functional view emphasises prediction, generalizability, causality and control. This view sees culture as a variable among many others and as something an organization "has". Such a view considers that culture can be consciously managed to improve organizational performance due to its causal nature. Consequently, the functional view reduces culture to limited aspects that are perceived from an organizational performance point of view (Smircich 1983; Gajendran et al. 2012).

In contrast, a non-functional view explains culture as part of observable human behaviour, thus, is seen as something an organization "is". Informal aspects of organizations are seen as important and need to be explored to develop organizations (Smircich 1983; Gajendran et al. 2012).

BIM IN PRACTICE

Semi-structured interviews were conducted with professionals from the Birmingham, UK office of a multidisciplinary engineering company which has been established for forty years in the UK and now operates in twenty locations around the world with over four hundred staff. The interviews were conducted with an associate partner, two mechanical engineers, two energy modelling engineers, one structural engineer and one acoustic engineer. The interviews aimed to gain insight into the changes that occurred with the implementation of BIM and about their perceptions of BIM.

Although these people were engineers and so inclined to have a technological perspective and be supportive of technology such as BIM, this did not dominate their practice. For example, the acoustic and energy modelling engineers did not interact with any collaborative BIM software. Both disciplines believed that the inputs and outputs of their discipline are different in nature than other disciplines and that there is no need to be integrated in a merged building model. However, energy modelling engineers stated that if there was a plug-in which ensures the seamless interoperability between the model and their proprietary software they would use it. Nevertheless, they added that even in this situation they would doubt the accuracy of data entered by other parties and probably be cautious about using it.

Although the majority of interviewees were aware of the capabilities of BIM as a total project delivery approach, all the interviewees saw and used BIM merely as a design coordination platform. This means that i) even the disciplines interacting with BIM software (i.e. mechanical and structural engineers) create their design solutions the way they used to do in 2D form and then transfer it to BIM platform for clash detection and drawing generation; ii) BIM software capabilities are not being fully exploited and no object information other than geometrical information is entered in 3D models (i.e. schedules and specifications are created as separate text documents to be printed out and not linked to models). While the software that the structural engineer uses for structural analysis has an export feature to the collaborative BIM tool, this is not the case for mechanical engineers because they create their preliminary solutions through sketches and 2D drawings.

The reasons identified by the interviewees to explain their approach to BIM merely as a design coordination platform are listed below:

- The only perceived advantages of 3D modelling are early clash detection and better design coordination.
- The amount of the detail required in 3D modelling is non-supportive for the preliminary design phase of mechanical engineering discipline.
- Drafting work cannot be delegated to CAD technicians anymore because 3D modelling requires decision making during modelling, thus, increasing the workload of mechanical engineers. The time needed to embed all design information (visual and non-visual) into the model is not perceived as adding enough value in return.
- Structural and mechanical engineers considered the necessity to fully detail 3D models which then generated 2D drawings as a negative effect.
- The amount and type of information that contractors use has not changed. They don’t use 3D models and ask for 2D drawings.
- There is a belief that the control and tracing of the non-visual design information (e.g. specifications) is more difficult in the model than when it is in spread sheet tables and/or text documents.
- Senior engineers sign off design documents but do not have BIM knowledge.
- Software interoperability problems are not currently resolved.

On the other hand all the interviewees agreed that implementation of BIM improved coordination within the team and between the teams of different companies. They stated that the nature of 3D modelling which is transparent and which requires design decisions to be made earlier increased communication. Increased communication, clash detection meetings and better visualization made people to better understand others' work. However it was also stated by the interviewees that unlike communication, the collaboration between the parties hasn't improved. All the interviewees see BIM as an important part of the future of the construction industry but it needs to be supported by training and go through significant rationalization.

DISCUSSION

The interviews were analyzed to understand BIM practices in: i) adopting BIM tools ii) shaping business processes, and iii) addressing collaboration which revealed the significance of the added complexity introduced by BIM.

Making sense of use of IT in BIM

The interviews revealed that the only pure technological problem for the use of BIM merely as a design coordination platform is interoperability. All other reasons show the importance of making sense of the use of IT for people to make them use a particular IT, just like human-centred perspective of IT would suggest. A technology-centred perspective would assume that the functionalities embedded in IT would be used by its users. However, despite better visualisation and more sophisticated tools provided by BIM software, all the disciplines interviewed have created their design solutions as they used to do in the 2D tradition. The major reason for this is that all the interviewed disciplines believe that the creative design processes they used previously are good enough and they do not need to be changed. For example, mechanical engineers keep using sketches and 2D drawings for their preliminary design and they find this method to be faster and more efficient. They claim that 3D modelling requires too much detail to be entered into the model from the beginning and that this much detail is unnecessary when multiple design solutions are being evaluated to choose the best one. Furthermore, pen and paper are not just old fashioned tools that they use to communicate their design but are part of their creative process.

A similar situation is reported by Harty (2008) for the case he studied where a planned project based shift from pen and paper sketches and 2D CAD drawings to 3D modelling faced strong resistance from the design team. He claimed that people resisted because the implemented vision and artefacts did not account for the other material objects that were an integral part of designing and drafting. Consequently new processes were seen as discontinuous with existing ways of working. Gustavsson et al. (2012) explain that design is a proactive and iterative process where the designer uses a unique combination of practical, theoretical and tacit knowledge which cannot be achieved by any technology. This particular nature of the design process is currently not being supported by IT solutions. Therefore, designers use a combination of different methods (i.e. both manual and technology based) and only use IT when they make sense of its use.

Practice is Business Process (BP)

The company's BIM strategy stated by the associate partner and most of the engineers emphasised BIM as a "selling point" and "catch phrase" for the company. Thus, there was a necessity to use BIM but not a need for extended use. This situation, to some extent, gives more power to people using BIM tools in determining the scope of the BIM related change in BPs. Although BIM tools have capabilities beyond design coordination and interviewees are knowledgeable about them; BIM practices played a critical role in determining the scope of the BP change and led the company to use BIM merely as a design coordination tool.

Automatic clash detection capability and 3D visualization are the obvious, immediate benefits of BIM even in cases where any non-geometric object information is not entered into the model. Therefore, it can be argued that under a vague and non-leading organizational strategy, it is only the immediate benefits that are adopted. In practice then, BIM tools are only used for the tasks where users made sense of the BIM way of working, in this case design coordination. Thus, BPs are not evolved in the direction of BIM's capabilities but had minor changes with implementation of BIM because of the way it is used in practice. In this case, people's use of BIM was the limiting factor however as this didn't disturb current strategy and technological capabilities, a pragmatic congruence is achieved. Moreover, the positive current and future perceptions of the interviewees about BIM, despite their limited use of BIM technology, can also be related to this congruence. This example demonstrates the power of practice in shaping BPs in organizations.

This is in line with Linderoth and Pellegrino (2005) as they showed the way IT is used in practice is an important factor in determining the scope of realized change in IT implementation projects. They identified that strategy, the perceived nature of technology and the use of technology are inter-related and inter-dependent with varying emphasis on the different relations between these three elements according to the stage of implementation and use. In accordance with our findings, they claim that congruence should be established between the strategy, the nature of technology and the use of technology for the change to occur.

BIM Tools, Interoperability and Collaborative Culture

All interviewees agreed that implementation of BIM improved coordination within and between the project teams. Engineers interacting with BIM software stated that 3D modelling made the design more transparent and this pushed team members to think more about their solutions and its consequences earlier. In the 2D tradition, different service headings could work separately and meet less frequently for coordination. However, in 3D environment there is a need for people to contact each other more to understand others' solutions before proceeding with theirs. Interestingly, when the definition of collaboration was made explicit to the interviewees as “creation of collaborative and innovative solutions with shared goals”, they stated that the level of collaboration hasn’t changed. Furthermore, one of the mechanical engineers stated that “sharing (of the model) doesn’t make a better team”. Interviewees stated that design meetings focus on problem identification and discussion rather than the creation of collaborative and innovative solutions. Interviewees saw the 3D model as a facilitator in design meetings with the common, understandable and visual information it provides. However, they also stated that this enhanced understanding of other parties’ work doesn’t necessarily encourage them to collaborate.

Similar findings were presented by Neff et al. (2010) who argued that while there are instances where BIM tools may improve collaboration and communication within the teams, it is not due to its ability to close the informational gaps between disciplines. Furthermore, they argue that the lack of flexibility of the information created and stored with BIM tools hinders inter-organizational collaboration and group working. They argue that BIM tools reflect and amplify the disciplinary representations instead of supporting collaboration. Moreover, Homayouni et al.’s (2010) findings suggest that the theoretical categories of successful collaboration are the same for BIM enabled projects as projects without BIM. Similarly, Dossick and Neff (2011) present transparent and reliable technology and communication as the key factors for effective inter-organizational team work with a strong emphasis on the importance of informal, active and flexible visual communication. Therefore, it can be argued that the belief that improved information sharing capabilities (i.e. better interoperability) leads to improved collaboration is not correct. Thus there is not a direct causal relationship between the technological tools alone and change in collaboration culture.

Over Simplification of a Complex Realm?

Construction projects are characterised by their technical and organizational complexity (Dubois & Gadde 2002). Therefore, the construction industry should be ready to face the added complexity when implementing BIM. However, complex systems require the whole to work beyond the capacity of the details (Bertelsen 2004). The adoption of technology-centred perspective of BIM leads to an abstraction of real life practices inducing a limited understanding of their effects, thus severely curtailing sense-making. Koskela and Vrijhoef (2001) make a similar argument stating that one of the main deficiencies of the current construction theory, in terms of innovation activity, is its abstraction of uncertainty and interdependence. Consequently, business improvement attempts made from such an abstract perspective would have limited effects.

Managers and problem solvers should acknowledge the added complexity in the adoption of BIM and avoid having too many expectations from technology-centred approaches (Brown & Duguid 2000). It is argued that a balanced view of BIM should be adopted to understand the challenges of BIM and to create solutions. Moreover, the complex nature of this area should be embraced as an important input for problem statement, problem resolution and management (Brown & Duguid 2000; Bertelsen 2004; Gajendran et al. 2012).

CONCLUSIONS

This paper has demonstrated how the currently dominant technology-centred perspective of BIM requires a human-centred perspective to enhance our understanding about BIM developments. The extremes of views in terms of IT, organizational and people issues were presented from the literature which provided an understanding of the differences between the perspectives and a robust enquiry frame for researchers and practitioners. It was argued that due to the complex nature of construction projects, a delicate balance between the technology-centred perspective (i.e. which is characterized as simplistic, structured, deterministic, mechanistic and causal) and human-centred perspective (i.e. which shows a world of practice characterized as complex, unstructured, unpredictable, dynamic, and non-generalizable) is required to better understand the problems of BIM and thus to create positive change.

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