Clients' and Users' Perceptions of BIM: a study in Phenomenology

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Abstract

Although Building Information Models (BIM) are declared as singular and correct expressions of buildings, these still are merely representations of designs and complete buildings. The digital model is not the building and is not the design. The digital model does allow visualisations of the buildings allowing stakeholders a new perception of the building through its 3D representation with the ability to choose viewpoints and to travel dynamically, but virtually, through the represented building. This paper explores what is perceived by clients and users in building information models using phenomenology. It emphasises the differences in perception and explores the meaning of this for design and construction. The work has involved interviews and experimental studies with users using models in different forms including static 3D, walk through(s), 2D and room data sheets. The results show that different people view models with a difference in focus, intent and expectation. This makes models not have a singular and correct expression which means that the engagement with stakeholders still needs to be worked on and actively managed during design and construction. Digital tools then are not finished expressions but examples to be worked with dynamically and used to demonstrate differences proactively to help work on these different perceptions so that a higher performing building can be produced. The future of BIM to deliver value for both the client and users then lies in its ability to provide soft informated representations.

Keywords: Building-use, users, performance, perceptions, representations

1. Introduction

The application of digital technologies is developing rapidly and is now being adopted by the Architecture, Engineering and Construction (AEC) industry. In AEC, Building Information Modelling (BIM) is considered to be the current flagship that is the new improvement solution for the construction industry as it allows the transition to better communication of information so that it can be shared and exchanged between different stakeholders (Drettakis *et al*., 2007). Bullinger *et al*., (2010) have pointed out that although the existence of such technology has

supported the integration of multi-stakeholders, the involvement of the end-user has so far been limited; this is considered to be a major issue in current approaches. This is due to the promotion of BIM, more as a vehicle to drive productivity and efficiency for the construction industry, rather than to increase value in its outputs (Miettinen and Paavola, 2014). This is hiding the client and user perspectives on BIM and not utilising its potential for radical improvement.

The paper is part of a larger research study on enhancing building performance in buildings during design using BIM. The focus of this paper is on the way clients and users perceive their buildings in design and how BIM might be used to allow user input. The key point is the way that BIM represents the building to help this process. The issue of representations in building design is not new but the development of digital representations is explored. This presents theory of how BIM is perceived in a more phenomenological manner where it is the subjective experience that is crucial. This paper uses data from interviews with client teams and interviews and experimental studies with users. The latter, used BIM models in different forms including static 3D, walk-throughs, 2D plans and room data sheets. The results are explored both comparing the positions of client team and users and emphasising the user perceptions of BIM and their particular needs. The conclusion identifies how BIM needs to be modified to handle soft information to enable a more user involved design as well as greater understanding of user needs by the client team.

2. Literature Review

2.1 Design and Users

There has been a growing movement to make design more performance orientated (Kolarevic and Malkawi, 2005). This concept is embedded in Vitruvius's 1st century BC requirements for buildings of commodity, firmness and delight as well as the more detailed and quantitative design quality indicator (CIC 2003). The ratio 1:5:200 (1 = construction cost; 5 = maintenance and building operating costs; 200 = business operating costs) (Evans *et al*., 1998) focuses attention on the fact that the business operation of a building costs several orders of magnitude more than its design and construction costs. Even though this ratio is challenged (Hughes *et al*., 2004), the idea that buildings should be designed to assist the work of the business is crucial. However, there is a gap between the expectations of design and how a building actually performs (Bordass et al., 2001). Jensen *et al*. (2011) and Sanoff, (2000), argue that involving users in the design and operation of the built environment taps into their knowledge and preferences and so creates spaces that work more effectively. Vischer's (2008) built environment theory identifies building use and user as critical design determinants of buildings. Sanoff (2000) has pointed out the difficulty of delivering this experience, due to, for example, the gap between the demands from the users and the design provided by the architects. Forty (2000) claims that building space appears to be a homogeneous concept, partly because architects consider space via representations (abstract space) rather than experiencing space by living it (lived space). However, Hensel et al. (2009) argue that bridging the gap between lived and abstract space requires another level of complexity, which is stopping any change from current practice. The solution to greater building performance requires user involvement and the handling of the complexity of technically undertaking this and including it in the process (Barratt and Stanley 1999). The sophistication and integration provided

by BIM offers the opportunity to address this problem explicitly but this has only currently been researched in a limited manner.

2.2 BIM, Design and Users

Building Information Modelling provides a repository in centralised data location for a full design model integrating structural, architectural, mechanical, electrical and plumbing (Kensek 2014). Its use in design has developed rapidly as a tool for composition, testing and construction delivery with full national government support. There is a complexity associated with the technical side of BIM within its software and hardware that limits the size of the model and their ability to represent all the information explicitly, and this remains a problem within the AEC industry (Johansson *et al*., 2015). This creates a challenge for the development of BIM for it to be useful for design rather than just as a repository for the end design (Whyte 2013). There has been little consideration of challenges associated with user involvement during the design stage (Kunz and Fischer, 2009). Kim *et al*. (2015) have reviewed user involvement during both pre and post construction showing how simulation tools can be employed by architects to understand the relationships between users and spaces. They concluded, however, that one of the current challenges is 'formalising' this involvement process, and there was a need for further inquiry into virtual design and construction tools. Khemlani (2008) reported that 3D and 4D simulation (e.g. Navisworks) have enhanced users' understanding of the design allowing a third person view to support users' in obtaining a sense of scale, but this navigation is relatively simplistic. There are some recent attempts to involve end-users and facility management; e.g, Lee and Ha (2013) have proposed a BIM-based tool for residential buildings to meet different customer needs which would allow them to be involved in decision-making. It was found that collaboration using the tool helped to meet customer needs for the optimum use of space. Shen et al. (2012) proposed a user activity simulation and evaluation method (UASEM) that aimed to enhance the user's visual experience of the built environment, but did not explore whether such simulations have an impact on improving design solutions. Oerter *et al*. (2014) pointed out that the use of avatars within the BIM environment can support by providing feedback to the users' and clients. None of these studies acknowledged the problems of perception of BIM environments.

2.3 Digital Representations and Users

The shift to a digital world in construction involves the creation and use of digital representations. According to Allen (2009), 'representations' are an entire intellectual and social construct that allows the imagination to construct new fragments of reality. Representations are the interface between the data and individuals as the representation conveys meaningfulness in a form to enable the data to become information. Thus, the design process requires a study of representations suitable for users to be integrated into the design process. Many theories of knowledge-use see mental activity working on representations thus it is possible to see representations as reality (Zhang and Norman, 1994) and for computing to work as this representation as reality. This has been opposed most vociferously by philosophers such as Dreyfus and Dreyfus (1986) who argue that thinking can occur without mental representations and Lorino *et al*., (2011) suggest that external representations have a communicative role in the activity itself. According to Hatfield

(2003), the visual experience aims to represent a visual space in relation to the physical space. In the study of visual space, it is often assumed that the observer has an internal representation of surrounding physical space where he/she attempts to measure properties of visual space to establish how well various properties of physical space are preserved in the mapping to visual space (Loomis *et al*., 1992). Ishii (2006) argues that people have an active interface with digital information with two components: control and representation. These can also be described as input and output where controls refer to what input users provide to manipulate information, while representations refer to what is perceived with the human senses.

There is a growing body of work on the phenomenology of digital environments. Turk (2001) explored how the product models in BIM are not as conceptually robust and material as they are presented and discussed. Meaningful work requires engagement with people with virtual worlds which has been reviewed by Farr et al (2012) who call for the greater use of the concept of embodiment to support user interaction.

3. Research Methodology

This research reported here sought to gain a richer understanding of users' and client's perceptions of BIM with a view to using it to improve user involvement in design. Given this problem of alternative perspectives, the research question was set to determine how BIM might help this situation during the design phase. This study adopted a critical realist position (Mingers 2000) and used qualitative methods. The study investigated three case study building projects at different times of their design, construction and operation phases all of which had used digital design. Two of the buildings were university teaching blocks and the third was a local authority office. Data were collected using semi-structured interviews with client design team and users and an experiment where 2D and 3D representations of the buildings were shown to users who at the same time answered questions in a questionnaire. Overall, the study involved four participants representing the client side, and nine participants representing the building users side.

It was recognised that the building users' perspective is best conceived phenomenologically. A phenomenological position focuses on the subjective experience of individuals thus is concerned with being, consciousness, and awareness (Seamon 2007). As such individuals experience a context, i.e. the building or work on a building, modified by their own beliefs about themselves and their well-being. Users' perceptions are created from the interaction of this 'being' with the physical and social environment provided by the building. In Christopher Alexander's terms this requires a wholeness of conception of a building (Seamon 2007). The study was phenomenological in that it asked questions into the thinking and feelings of the respondents. In particular, it asked questions about their lived experience which composed their perceptions. The phenomena in this research where firstly the way the design team and users saw buildings and secondly the way they interacted with the representations of the buildings as generated by BIM models. In the first phase, the study asked open ended questions about the nature of building performance in the buildings they engaged with for their work. It did this without defining performance in order to stimulate a subjective response. These responses were analysed in a form of discourse analysis to draw out the phenomenological perceptions. In the second phase, the

study aimed to gain insights into the respondent's engagement with BIM. The case study was delivered using BIM, and thus the client was already familiar with the outputs of BIM whereas the users had to be briefed on what BIM was in order to gather meaningful data. A questionnaire was used to collect data from a group of respondents as they were shown 2D representations and 3D walkthroughs. However, the questions were again open-ended to allow the subjective impression to be captured. Different types of spaces within the building where shown and the participants had to write down what their perceptions were of the represented spaces. The data were analysed to explore how users could assist client teams during design.

4. Results and Findings

Different Perspectives

The first set of data was gathered during interviews with both the client team members and users about the buildings they were engaged with for their work. The data showed a number of characteristics that separated the building client team and the building users. Firstly the users' requirement for performance is concerned how they could act in a space.

'I want an environment that allows me to perform a certain task or daily job comfortably' (PS u1, 2013)

"Building performance is gauged by how comfortable an environment is, so it provides the right temperature, access to fresh air and the right level of lighting" (WS u1, 2014)

"In terms of community space, it is any space that can take you completely out of work, so you can sit, relax, allow to do work, but most important that it makes you feel like offline" (WS u2, 2014)

The users' expressions do contain functional aspects like temperature, fresh air and lighting but these are actually subjective characteristics. However, they do refer to a way of being in the building environment that involves performance supported by an environment that is beyond their aware attention. The notion of 'right' is here self-defining giving it a very subjective character. This is emphasised more when users express problems of the space.

"Some problems we have now, some facilities don't fit within their spaces, and we don't necessarily have the right furniture" (PS u3, 2013)

"the furniture within the open spaces is too big, and some of the sockets do not sit down properly" (PS u3, 2013)

"It is important to consider the positioning of some facilities such as projectors, one of the major concerns I have now, is whether our current spaces provide the right environment to work or lecture within" (PS u3, 2013)

"I think as a team we don't really have enough space to perhaps store some of the things that we need, so when you work, you want things, you want the things around that you would normally need, so you want them to be accessible and to hand, but it becomes hard when things are pile up because you haven't got enough space" (WS u2, 2104)

This draws out how users see things particularly which get in their way and so come to their attention. This is both as an individual experience but also a social experience e.g. the need for a team to have things at hand to perform their task.

The building client team performs a role as well as using experience, both of which centre on the delivery of buildings.

"For XXXX building, we tend to drive specification to a need, so what we are really controlling over, not necessarily the legislative side, but more a specification side, so when you walk into room, you still feel like a university building" (PS c2, 2013)

'the space is defined by four sides with single or multiple accesses and designed to perform a particular function' (PS c3, 2013)

"For such a modern educational building, we had to ensure the balance between aesthetics, robustness and durability, thermal comfort, appropriate levels of natural and artificial light, energy usage, flexibility to suit changing uses, acoustic performance, capital budget and on-going maintenance costs, brand identity for the university," (PS c4, 2013)

"From my perspective, building performance is related to maintenance, energy and operation, and also all the systems within the building, so it's about maintaining all the level of understanding" (PS c1, 2013)

"I think that performance is about saving money, so what we are looking for is a cost effective building, value for money, deliver what we want for the occupants, and try and reduce as many issues as possible" (WS c1, 2014)

Clearly, this is much more technical view than the users' where problems exist in relation to what is deliverable and controllable against a functional brief and view of building operations.

<u>BIM and Design</u>

The second set of data gathered from the client team and users considered how BIM could help them see performance in design. The users' results are responses to 2D and 3D images. Although users are not proficient with building representations, these representations did provide the users with information. Firstly, in response to the static 2D images which were building plans:

Hard to get a real feel of size/ Doesn't show the scale (CS, u1, 2D, 2014)

Good for seeing layout of furniture/ Can't tell how many people will fit in room (CS u2, 2D 2014)

Certainly, the users did not feel that they could appreciate any spatial quality from the 2D representations. However, the 3D and dynamic images were also challenging:

Doesn't show colour/it might change feel if [colour] shown/ 3D gives better visualisation, but you can't visualise how much space your computer will take up (CS u4, 3D, 2014)

I hate revolving doors /Spaces don't look comfortable/ Desks look small – need to see what it looks like with the PC on it./ Cannot tell the space, ventilation, light (CS u2, 3D, 2014)

Probably stuffy, Small, Shared space / Unsure have ability to open windows /Room access is difficult to tell whether it is scan/lock or other (CS u1, 3D, 2014)

Users need details that are not important for the delivery model. The users were inclined to be upset by what they could not see. These details are needed as an experiential scaffolding to understand how the spaces can be used and how easily this is. The users did not trust the 3D representations; they thought they might be used to make it look attractive by using reduced size furniture or hide problems. This goes back to the organisational context within which the new building was being designed.

Turning to the client team, they saw 3D helping them with their role:

"The representations provided information on the areas within the building, and allowed me to gauge it against the brief" (CS, c1, 2014)

"The visualisation has provided accurate briefing on predicted space use by occupants" (CS, c2, 2014)

However, as these were experienced members of the client team, they did understand the inadequacies of BIM for delivering subjective performance information and how the users (or even non expert clients) were disappointed with the BIM representations; e.g.

"Spatially, it's quite restricted what you can do beyond an appreciation for the space itself, so one thing is that BIM in its current iteration lacks is that visual connectivity to the building itself so it gives you an understanding of the form and shape but not necessarily how it actually physically looks. So when people look at the model, they actually look quite disappointed expecting much more of a 3D representation of what's physically out there not just the shape and form." (CS, c2, 2014)

This was interesting as the client team promoted BIM strongly but from experience they also saw its current limitations for other than technical delivery.

5. Discussion

5.1 Users and Clients

The case study data explicitly shows that users and client team perceive the buildings in different ways. The client team's perceptions are driven by their experience and need for building delivery producing a requirement to control and be explicit through measurement about aspects that they have specified. The users' perceptions are driven by their experience of working in buildings producing a need for comfort and ease of action. In a sense the two perspectives are connected but the users' perspective is describing a function in relation to their task. The client team has a more abstract view, not concerned with user tasks, but around measurable functions; but this abstraction can hide any problems of user tasks. This was shown by the client *(PS c2, 2013)* when demanding that certain specifications were delivered but these were not there for the occupants' needs. It is argued that the differences between the views of the client and users are not currently explored during design. Indeed, the client teams seemed somewhat reluctant to engage users, other than departmental managers, as they provided too complex or unspecifiable requirements, plus users gave often contradictory and unrealistic requirements which could be contrary to the client team's delivery objectives. The case studies also showed that clients have a corporate perspective on buildings as being expensive and their strategy is to cut this cost and make building-use more efficient; often referred to as space rationalisation. This was conducted purely at a space cost vs space area per activity level. Most often space per activity was set as a standard

for that activity throughout the building even making savings by explicitly reducing this standard globally by say 10%. Client design teams do not investigate the business performance of space and how this might enhance work or how their designs might impede work. The idea that such decision making might cost money from ineffective business operations was not in any way acknowledged. The users' perspective (e.g. *(PS u1 2013)* and *(WB u2 2014)*), had a focus upon the use of spaces in terms of how they operated as facilities and whether they provided comfort; thus, performance for users is much was very much more from their individual perspective and not from some general or standardised basis.

5.2 Perceptions on digital representations

Not surprisingly given their drivers for buildings, the client team and users also perceived the digital representations (2D and 3D) presented to them differently. Looking at the client's side *(e.g. CS c1, 2014)* their perception of the representations is directly associated with the brief they had formed at the design stage. Some of the representations supported the quantitative aspects, such as area and occupancy level. Others were used as a reference to aid them in visualising aspects within the 3D representations such as furniture type, access to services (e.g. electricity sockets) and lighting (e.g. *CS c2, 2014*); which do support predicting how the space is can be utilised by the occupants. However, the client team use the visualisations and the completeness of the model to satisfy them about the successful delivery of the building.

The case was different from the users' perspective, as each representation triggered a number of concerns. They struggled to use the representations to experience the spaces. According to Oliva *et al*. (2010: 108) "we often acquire information about our surroundings by moving our head and eyes, getting at each instant a different snapshot or view of the world". The users try to use both their past experience as well as the representations to make sense of what they saw. Their concerns related to both operational and usability aspects but also the inadequacy of getting a feeling for the space. For instance, the user *(CS u1, 3D, 2014)* had concerns about space accessibility and whether windows could be opened. We argue that the gap between client and users is phenomenological where the client's concern focuses on the tangible aspects of the built environment whilst the users engage with intangibles that directly influence their experience.

5.3 New Interactions with BIM

The inquiry then into whether BIM can support the use of user experience in design is problematic. In this study a pragmatic approach was adopted to see what could be seen from the BIM models. Whilst acknowledging that virtual environments have been used as a collaborative design tools (e.g. Iorio *et al*., 2011), which allowed information exchanging and sharing; these do not acknowledge the differing information requirements from the client's and users' perspectives. The current immersive virtual environments, which allow a sense of presence (e.g. Heydarian et al 2015), do not recognise how such environments can support the users' input into the design. The visualisation tends to focus on objects (e.g. Heydarian et al 2015) as this is easily provided by a virtual world that people experience in games. The difficulty of distinguishing a gaming virtual world and an understanding of the experience of a real physical world then becomes

critical. The IT world is obsessed by creating simulated reality even when this is not possible. The evolution of virtual reality applications has focused on the interface provided to visualise objects rather than what information is needed to design user productive space.

Current visualisation does not allow people to feel a space merely showing a connection of detail. This detail is all that is necessary for computer games where the gaming aspect, e.g. of the action hero killing elves, is set within a context. In the building design world, it is the context and our engagement with it that is the critical aspect not the detailed representation of the objects. In fact, it may be that, because perception is phenomenological, simple representations that are engaged with interactively and dynamically, may be more successful. Such a change in outlook for digital representations requires a change in aspect and intent. The intent has to be about inducing feeling and experience and the aspect has to be more holistic. The idea that the interaction is metaphorical rather than simulated reality (Dade-Robertson 2012) and the phenomenological aspects (Murray 2000) needs to be explored in greater detail. Future interaction with BIM would require further constructive approaches where lived experience is informing the digital experience, which potentially can support producing more informative representations. This needs to be undertaken within a metaphorical informating environment involving a social situation, an interactive process and a dynamic enquiry.

6. Conclusions

Given that there is much evidence that buildings do not meet user needs (Bordass et al, 2001) methods are required to address this. The advent of BIM provides the opportunity to engage users more in design and so to deliver buildings that perform better. This paper has adopted a phenomenological position on the use of BIM. Using a study of client team and user views of BIM, it established that they have different needs and different perceptions of building performance and BIM. For the client the performance is described by functional and quantitative aspects that can be controlled for building delivery. However, for the user, the performance is experiential and so is not containable by functional terms or aesthetic considerations. This phenomenological aspect has not been acknowledged and certainly does not feature in the current BIM debate. There is an assumption in the BIM promotion that visual representations are all that is required to accommodate experience where this paper demonstrated that this is not the case. Although gaming worlds are experiential they have not been created for this application and engage people at a superficial level.

The evidence suggests that it is not virtual realism that is needed as regards experiential engagement; it is a user interactive process with a range of information that can elicit experiential understanding. Some of this may be quantitative or visualisations but other representations and interactive enquiry are needed. The paper suggests that BIM needs to support much softer information and this will be more metaphorical, interactive and developmental placed within a social situation of design. This also means that it is not possible to automate such activities and work is needed on the processes of design not just the product. The future of BIM then to deliver value for both the client and users lies in its ability to provide soft informated representations.

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