Building Information Modelling (BIM) for UK Housing: Exploring Potential Drivers and Opportunities to Deliver Better Customer Experience

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Abstract

The digitization of the built environment using building information modelling (BIM) is claimed to providing a more effective and efficient solution for meeting customer expectations. This paper seeks to explore the opportunities of BIM and digital construction for the housing sector. A review of current practices and initiatives used to deliver customer experienceis conducted, emphasising the need to clarify elements/factors affecting that experience, and what impact they impose on the housing developmentin the UK. A workshop was setup by various UK industrial partners to demonstrate the opportunities for BIM using a residential scheme. BIM-based applications and some analytical tools were subsequently used to demonstrate the opportunities to improve planning, fabric regulation and control, customer experience and supply chain management. Feedback from participants was obtained during the workshop highlighting the practical implications of using BIM. The paper concludes by illustrating the areas in which BIM can play a pivotal role in the development of the UK housing industry. Future work is also recommended to investigate the use of BIM to form an integrated framework for promoting better collaboration in the UK housing industry.

Keywords: Building information modelling, housing, customer experience

1. Introduction

For decades, the UK housing industry has frequently altered its processes, design requirement, building methods and quality standards (Farookhi *et al.*, 2010). This process of continual evolution seeks to align the sector with various market demands and government legislation, while simultaneously delivering a sufficient customer experience (Callaghan *et al.*, 2014). Successfully delivering customer experience is a quintessential ambition of contractors and developers within the UK housing industry. Yet, according to Ball (1996), consumer needs and preferences are hardly met because house builders rarely conduct research in relation to customer needs. This supports the claim that the house-building industry is producer driven. In addition, current surveys produced on customer satisfaction in the UK housing market are limited to larger companies that have merged during the economic crisis and hence, may not be applicable to the entire sector (House Builders Federation, 2015).

Customers' participation in house design has become widespread (Ozaki, 2003) because it affords them palpable benefits such as flexible plan forms and choice of different building materials (Woolley, 1994; Houvila *et al*., 1997). This approach combats recurrent issues such as re-designing the layout and waste of resources (Kotha, 1996). More importantly, as the market for house building in the UK is in continuous fluctuation (Wilson, 2010), customer participation can potentially support decreasing the uncertainty in housing demand, enhance customer confidence and assist house builders to construct houses that sell more readily. However, engaging customers within the house building process, requires reliable tools that allow ease of modification, flexible design and cater for customers concerns. This is because current tools (e.g. 2D drawings and material spread sheets) can propagate numerous errors when subjected to change (Eastman *et al*., 2011; Lim and Kim, 2006).

Building Information Modelling (BIM) represents an approach, which aims to create and manage information over the building's whole life cycle (Liu *et al*., 2012). BIM offers a flexible approach towards managing construction documentation, visualisation of building design and construction, cost estimates and comparison between different material properties (Garber, 2014). Ibrahim and Krawczyk (2003) argued that BIM data can be captured and presented in ways that are appropriate for designers, contractors, clients or vendors. This paper aims to investigate the value of BIM to deliver better customer experience in the UK housing sector. A triangulation approach is

adopted by assessing customer experience within UK housing, gathering feedback of house builders and developers on the use BIM applications during a master class and finally, conducting interviews with house owners to inquire into those elements/factors that affect their experience. Specifically, the master class involved an interactive seminar session held specifically for industry; this was not a formal taught course. Areas in which BIM plays a pivotal role are highlighted, and the paper concludes by proposing a framework that incorporates the client during the house delivery process.

2. Methodology

The housing sector comprises of different stakeholders who hold a myriad of views and opinions that are often contradictory with each other. Because, the focus of this research is on the use of BIM to deliver customer experience, emphasis was drawn upon builders, developers and customers who will use, buy into and benefit from BIM. In addition, as BIM can be considered new to the UK housing sector, the suppliers' use of BIM is limited, and highly dependent on the demand from the housing developers/builders (Building Services Research and Information Association, 2013). This, to some extent, places a high level of uncertainty when considering the role of BIM for the UK housing sector, and whether it can contribute towards enhancing long-term customer experience.

To counter any ambiguity involved in investigating the inherent value/benefit of BIM to support the delivery of customer experience, a triangulation methodology was adopted. Triangulation facilitates the capture of a more holistic image of the phenomenon under investigation, thus providing a richer argument to be formulated (Patton, 1999; Denzin, 1978). The data collection process consisted of three stages, namely: i) a review of relevant literature on current areas involved when assessing customer experience; ii) the assimilation of feedback received from builders and developers on various BIM-based applications during a master class event using a life case study on a featured UK house; and iii) conducting interviews with house owners to elicit information and perceptions regards their experiences, requirements and concerns about the UK housing industry.

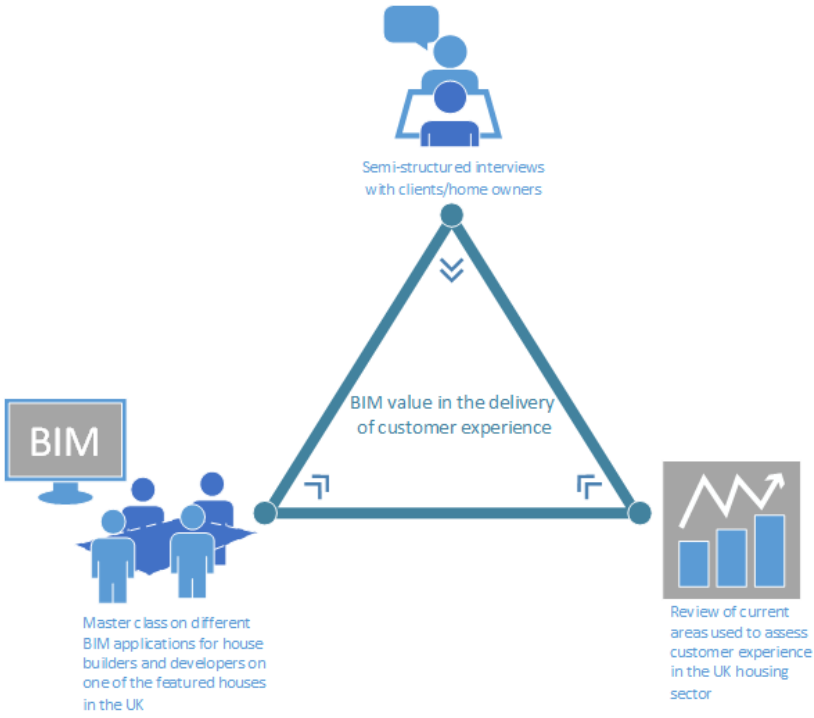


Figure 1. The elements involved in triangulation for this research

The first stage reviews the current approaches adopted to measure and improve customer experience, which can be claimed to be highly subjective and mostly pre-determined by the house builders. According to the UK National New Home Customer Satisfaction Survey (HBF, 2015) (which involved 31 house builders), the current areas that are being assessed are: quality of the home; completing construction on time; internal design and layout of the house; service provided by the builder during the buying process; conditions of the house from the moving-in day; handover process; external design of the house; standard finish of the house; external layout of the house; storage area in a new house; defects and problems reported; problems vs. expectations; and number of problems reported. However, using quantitative representations to assess customer experience is simplistic, as 'experience' itself is a subjective and complex phenomenon. In addition, it is also realized that customer experience tends to be mostly derived by the perception of the house builders whose focus is on assessing customer experience based on pre-determined parameters rather than

inquiring into those elements that drive this experience. This review highlighted shortcomings of the current method used to evaluate customer experience and importantly, clarified the need to inquire into the areas being evaluated, and what are the elements that influence it. Therefore, the following stage, sought to investigate what the key elements that influence customers' experience were through the use of various BIM applications.

The second stage sought to form an interactive master class, which included developers and house builders from the West Midlands region in the UK to demonstrate the use of various BIM-based applications. There applications used were: Autodesk Revit (Architecture and Mechanical), Lumion, Infraworks and Sefaira. Autodesk Revit (Architecture and Mechanical) was the starting point used to construct the working BIM model because it enabled inquiring into the materials specified, materials' properties and layout solutions for mechanical systems (e.g. hot and cold water supply). Lumion was then used to provide better visualization by allowing the user to freely walk within a 3D virtual live render environment. To represent site planning, Infraworks was used to demonstrate the house model on site using actual geographic data obtained through 'Bing maps' (similar to Google maps, Bing maps is a web mapping service); this facilitates external context setting such as surrounding buildings, services and infrastructure. Finally, sustainability assessment was conducted using Sefaira, which is an online energy analysis platform that utilizes various parameters such as the amount of day lighting, orientation and materials used. The use of Sefaira was beneficial because it allowed comparison between multiple design solutions, recognising parameters that influence how sustainable the built environment is, while providing better visualization (Aruofor, 2014).

The final stage employed semi-structured interviews with a sample of clients/home owners from the West Midlands to ascertain their needs and what influence their experiences. Due to the availability of the sample group targeted for the interviews, saturation was used to determine the sample size (Mason, 2010). The saturation point was reached after interviewing 12 different clients/home owners. The focus of the questions related to building performance, decisions regarding choosing the location, information requirements on the built property and whether clients/ home owners would be involved in the process of designing the property.

The BIM Masterclass involved contractors and house developers from the West Midlands (UK). As a generic statement, contractors had a clear idea of what BIM was and how it could be utilized whereas conversely, house

developers, were more interested in the inherent value of BIM and how it could improve customer experience. Based on the feedback received by the house developers, it was important to further inquire into customers' desires and needs; where this will have an impact in multiple ways. First, it would identify any gap(s) between what the developers' and house builders'consider to be customer satisfaction, and what the customer expects. Secondly, this would fundamentally support identifying where BIM can contribute to enhance the customers' experience. Therefore, to inquire into customer needs and desires, semi- structured interviews were conducted with a number of clients within the West Midlands area, so that it aligns with those involved in the BIM Masterclass to provide a more coherent analysis. The primary focus of the interviews was on what makes a well performing house/property, concerns in relation to both the built property and its location, desired information about the property and their future input if they are involved during the design process. It was important to acknowledge the level of subjectivity expected from the interviews, and therefore textual analysis was used to derive meaningful answers (presented in Table 1). According to Frey *et al*., (1999), textual analysis allows analysing qualitative contents, so that a meaning can be extracted and used by the researchers to provide meaningful analysis.

3. Results and Discussion

3.1 Results

This section presents the findings from both the BIM Masterclass, which involved developers and house builders, and the feedback gathered from the interviews conducted with the clients. From the BIM Masterclass, both developers and house builders provided various benefits of the use of BIM in the housing sector. They also highlighted those benefits that can contribute towards improving the customer experience. The top four benefits linked to customer experiencewith BIM highlighted by developers on the day of the BIM housing master class are the following: i) improved visualization and design accuracy for the end product; ii) ease of whole life cycle information retrieval; iii) improved building performance; and iv) better opportunities to collaborate through the ease of mass customization. These findings form a baseline, which can be used to link with the feedback gathered from the interviews with customers. More importantly, both developers and house builders will be more informed about customer needs, and how the use of technology can support its delivery. Research conducted by Lee and Ha

(2013) supports the use of technology to enhance the customer experience. This was accurately demonstrated on the day of the BIM master class and it was established and widely agreed upon that BIM allows for the enhancement of the customer experience.

Regards the findings from the interviews, textual analysis was used to categorise the collected data within the themes identified previously. Table 1 below outlines the categories explored during the interviews, and the most commonly occurring response among the sample group.

Table 1. Results categorized based on the semi-structured interviews.

Performance	Concerns on the newly built properties	New Site Location Concerns	Use of Information transferred	Input
Functionality Energy Efficiency Good choice of Building materials Comfortable: Garden space, Thermal performance, Natural daylight, Good infrastructure	Price Built material quality Designing small space Energy efficiency Expandability Orientation Site	Schools Amenities Affordability Quality Transportation links Distance to work Future developments Crime rate Parking Landscape	Future work to the property Extensions Renovation Position of services Maintenance Prevention of accidents	Quality of the material specified Renewable technology Sizes of rooms and garden space Internal layout Specs of finishes Parking area

Between these themes and questions explored, it was evident that in many cases, responses are re-occurring among different themes. For example, within the responses, it was spotted that age plays an important factor in terms of the needs required by different customers. Customer concerns can

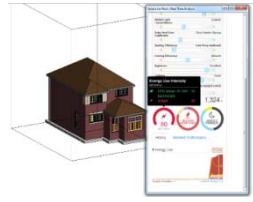
be categorized into the following categories: building performance; quality; location; and available information. Given these categorized results, it becomes evident that saturation point was reached with a fairly small sample number. Most of the concern outlined by the customers differed very little from each other when discussing the themes outlined.

Referring to Figure 2, the image on the top left shows the original Revit file with its mechanical, electrical and plumbing (MEP) family types included in the model. The image top right shows the use of Infraworks to set out the house in its site context, placed in its geolocation. The bottom left image depicts a live render plaform used to navigate and visualize the proposal, while the bottom right image depects the use of a live energy analyis is plug in with the native revit file, Sefaira.

a) MEP layout (Autodesk Revit 2015)

b) Site Planning (Autodesk Infraworks 2015)

c) Visualization (Lumion 4.1)



d) Energy Analysis Model (Sefaira Plug in)

Figure 2. BIM applications used during the Masterclass

3.1.1 A Framework of the Customer Experience

The following framework (refer to Figure 3) highlights the areas of client engagement throughout the design development of a project. At the pre-

design stages clients can inform the brief with design requirements. This then feeds into the design stages where client engagement can be split into concept and technical stages - both can inform the developers at these instances. At the concept stages client involvement can be restrictive towards site related concerns. For technical design stages, clients may be offered a limited array of design optimization choices based on existing specifications and alternatives post tender stages, to minimise any detrimental cost effects through change of specification. At the construction stages, developers can report upon relevant snags, which have been resolved. These will then be relayed into the most up-to-date version of the BIM model, which is then made available to the customer for future use. This information exchange (post construction stages) will help inform any future homebuyers.

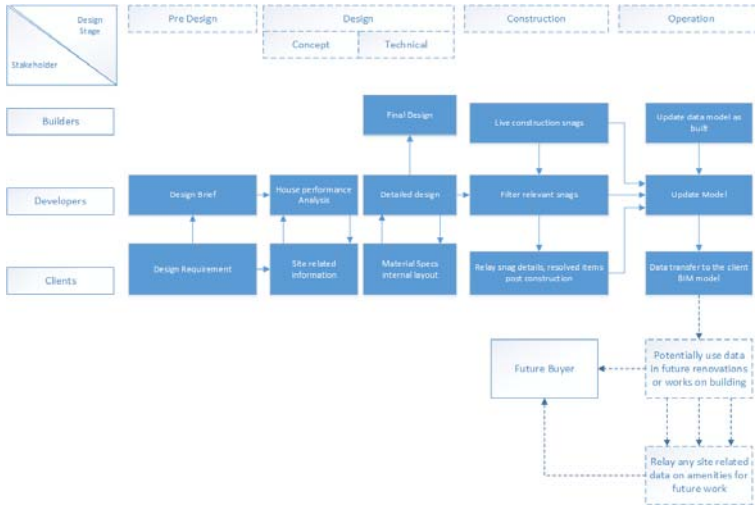


Figure 3. Framework of the Customer experience

3.2 Discussions

The results showed that by categorizing the answers, the key drivers for customer satisfaction in the housing sector could be readily determined. BIM can potentially allow greater client engagement in terms of involving them during the delivery process as well as transferring useful information to them after the project completion. BIM can also provide efficient and flexible design solutions to deliver sustainable houses. Therefore, the following sections will discuss the findings presented in the previous sections. Three main areas are presented, namely: BIM to provide a client engagement

platform, client involvement during the delivery process and information transfer to the client.

3.2.1 BIM to provide a client engagement platform

Within the construction industry, there are many elements that contribute towards the success of a project including construction processes, procedures and policies. More importantly, it is those stakeholders who are involved in the project that drive that success through the way they collaborate, share and exchange information (Sidawi, 2012). The findings showed that customer experience should be considered from multiple perspectives. From one side, builders and developers assess customer experience quantitatively, taking an abstract stance, which aims to look at certain aspects without inquiring into factors that influence these elements. Alternatively, interviews with customers showed that experience is associated with acknowledging their various concerns at an early stage in the house delivery process. BIM provides aninclusive environment where the client involvement is not terminated by the time they submit the brief, but instead provides a platform for continuous engagement with the client.

3.2.2 Client involvement during the delivery process

Both housing developers and builders acknowledged the possibilities of this engagement during the BIM master class. They pointed out that BIM could potentially support the delivery of better design accuracy whilst enhancing visualization. From the customers' perspective, many design related elements to can be seen from the results (refer toTable 1) when looking at the concerns about the newly built property such as building materials, quality, energy efficiency, size and orientation. It was demonstrated during the BIM master class that some BIM-based applications could contribute towards addressing these customers concerns such as the use of Lumion to visualize the indoor environment and building materials and Infraworks for orientation, positions of services and the landscape with the possible future developments on site. Lee and Ma (2013) have developed an application (CIBIM), which is a BIM-based application that aims to deliver customer-oriented designs. Furthermore, it was concluded that involving customers during the design process is beneficial to meeting their needs and support designers to develop more efficient solutions. Therefore, it can be realized that BIM offers the opportunity for better client engagement with the ease of incorporating their views and concerns.

3.2.3 Information transfer to the client

During the delivery process, information is created to aid various construction processes, which mainly support builders and some are kept with the developers after completion. However, there seems to be limited focus on the information that can be used after the delivery process. The findings showed that customers prefer to have more information about their property in terms of various changes throughout the delivery process, and also information that are useful after completion such as services, maintenance and possibility to have extensions. As noted by house developers during the BIM master class, BIM-based applications such as Autodesk Revit would enable them to keep a digital record of the various systems (mechanical, electrical and pluming) related to the property, which can then be passed to the customers upon their request. They also claimed that BIM would enable them to update the house model with a digital record of the snags and defects occurring during construction; where this will have a direct impact on customer satisfaction level (Callaghan *et al.,* 2010).

3.2.4 BIM to offer efficient and flexible house design solutions

Inevitably, the government is striving towards the delivery of efficient and zero carbon for the UK housing industry by 2016. This sets a constraint in terms of complying with all customers' requirements (e.g. building materials or shape), which often needs to be modified to align with the Code for Sustainable Homes (CLG, 2008). The findings showed that some of these changes could impact customers' experience such as the layout of the house, layout of the spaces and their size, orientation and many others. Builders and house developers have acknowledged the complexity in reporting all changes to the customers, as this would impact the overall delivery process. In addition, it was acknowledged that meeting customer preferences can be limited by the construction lead times, which implies that customers have limited options in terms of customization. However, during the BIM master class the use of Sefaira recognised various parameters thus allowing for more flexible modifications and near instant customer update. This was supported during the BIM master class when setting a task to change the layout, orientation and materials type on the house to allow for comparisons between different design solutions to reduce carbon emissions while complying with customer requirements.

4. Conclusions

This paper has investigated the complex nature of customer experience within the UK housing sector, acknowledging the value of BIM in enhancing that experience. Triangulation was used to explore current areas used to assess customer experience, builders' and developers' perspective on BIM benefits within the housing sector and interviews with the customers to inquire into factors/elements that affect their experience. Results showed that BIM could potentially provide more flexible and efficient approach where customers are informed about their property during and after the delivery process. The framework proposed could potentially act as a guideline on how customers/clients are incorporated within the delivery process when BIM applications are used. The paper provides a good foundation to recognize potential opportunities for UK housing, as the government aims to make BIM mandatory for the majority of construction projects in the UK. However, and in coping with the current concerns, customer experience is one of many challenges surrounding the UK housing industry, and thus, it is important to acknowledge that some of the other challenges such as economy, affordability and demand can set a barrier for BIM to be widely employed within the housing sector.

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