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MANAGING USER REQUIREMENTS IN SOCIAL HOUSING UPGRADING

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ABSTRACT

User requirement management is essential to improve value generation in construction projects. Requirements management is also vital in the context of social housing upgrading/retrofit projects, as such projects generally involve a poor consideration of user needs. Design science research is adopted to propose a process model to support the identification of user needs in the social housing upgrade context. Data was gathered through an empirical study carried out in an upgrading project in the UK. The model includes the use of BIM (Building Information Modelling) based tools. The model can help elicit users' needs and values through a participatory approach and the early inclusion of stakeholders in design decision-making. The process model contributes to an improved approach to managing user requirements, which will promote better value generation through retrofit projects.

KEYWORDS

User requirements, social housing upgrading, process model, building information modelling.

INTRODUCTION

Social housing upgrading provides an opportunity to solve housing deficits (Jensen et al., 2018). However, such upgrading/retrofit projects are challenging to manage (Carvalho et al., 2019). These challenges often result in overlooking user needs and consequent poor value generation (Blomsterberg & Pedersen, 2015). User value can be generated through the appropriate identification, processing and communication of requirements to assist design decision-making (Parsanezhad et al., 2016; Koskela, 2000).

Requirements management is essential in Lean. It includes capturing and eliciting client requirements, as well as monitoring the value generated from the user's point of view (Koskela, 2000). The approach involves gathering and processing information, and implementing strategies to support value generation throughout the design and construction phase (Jallow et al., 2014).

In the social housing context, there is a push towards upgrading/retrofitting the existing housing stock to achieve better energy efficiency. Such upgrading projects also can be an opportunity to increase user satisfaction (Kowaltowski & Granja, 2011; Baldauf et al., 2020). The conflicting interest among stakeholders and end-users highlight the need for a robust method to capture user needs during such projects (Koskela, 2000).

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POEs (post-occupancy evaluations), surveys and interviews are often used to elicit user requirements (Miron &Formoso, 2003). BIM can also be used for storing and structuring requirements, and connecting that information to building models for visualising requirements (Parsanezhad et al., 2016; Baldauf et al., 2021). This paper proposes a process model (adapted from Baldauf et al., 2020's paper) to illustrate user requirements management with BIM in the specific social housing upgrading process.

REQUIREMENTS MANAGEMENT

User requirements are often referred to as objectives, needs and expectations of the client/user in a construction project (Jallow et al., 2014; Kamara & Anumba, 2000; Kamara et al., 2002). The requirements management process incorporates initiation, development, adaptation and communication or requirement throughout the project (Barrett et al., 1999; Kamara et al., 2002).

Baldauf et al., (2020) proposed a client requirements management model with the use of BIM tools, which includes the following steps (i) identify-understanding the context and capturing requirements; (ii) analyse-interpretation of requirements; (iii) structure - organising the requirements); (iv) translate - conversion of requirements into product specification; (v) store ; (vi) prioritise - identifying the critical requirements from the categories from the users and stakeholders; (vii) communicate - liaise among stakeholders to facilitate design decisions to avoid conflict; (viii) assess - assessing the product development; to check if all the requirements are met (Baldauf et al., 2020, 2021; Bryde et al., 2013; Jallow et al., 2014; Kamara et al., 2002; Luo et al., 2010; Miron & Formoso, 2003; Pegoraro & Paula, 2017).

USE OF BIM IN REQUIREMENTS MANAGEMENT

BIM can facilitate collaboration between stakeholders by providing easy access to information (Jallow et al., 2014; Kamara et al., 2002; Baldauf et al., 2021). Past studies have developed computer tools allowing connections between requirements and product models (Baldauf et al., 2020; Luo et al., 2010). Figure 1 illustrates connections between client requirement management (CRM) steps and BIM.

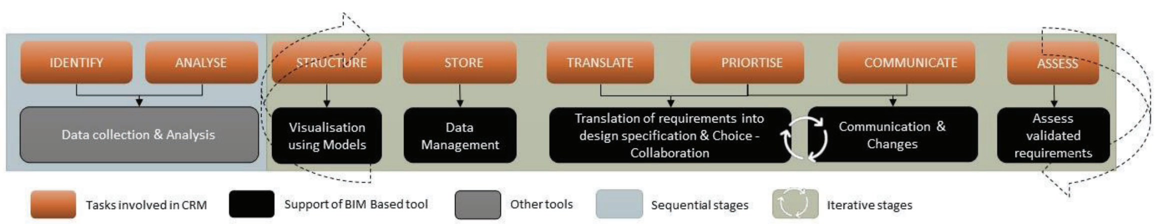

Figure 1: Connection between CRM steps and BIM

Potential BIM benefits in client requirement management are described below for further understanding:

- Data Management - BIM serves as data storage in a single centralised database system and facilitates easy and accessible information to the stakeholders through the 3D model. (Meadati & Irizarry, 2010). BIM allows the storage of requirement information so that the stakeholders' requirements can be accessed and reused at particular points of the project (Baldauf et al., 2021; Jallow et al., 2014; Luo et al., 2010). BIM stores lifecycle data requirements, and operational information that can be used in the requirements management (Jallow et al., 2014; Nørkjaer Gade et al., 2019).
- Visualisation-Visualisation is one of the primary characteristics of BIM and there are potential benefits when implementing 3D/4D BIM in the construction industry to

structure user requirements (Baldauf et al., 2020, 2021; Wang et al., 2014). BIM allows improved client service, using an accurate visualisation (Azhar et al., 2011).

- Collaboration - BIM allows collaboration through a faster and more effective process (Baldauf et al., 2020). All the stakeholders' requirements should be incorporated at the initial stage (e.g., the Briefing stage (Jallow et al., 2014). There should be a connection between the requirements and objects in product development, that will allow value generation in the process (Kiviniemi, 2005).
- Communication & changes- BIM allows changes in product attributes. It contributes to the communication in real-time changes in requirements that can be refined in the model recurrently (Awwal et al., 2022; Luo et al., 2010). BIM provides quicker simulations to simplify the generation of alternative design solutions (Azhar et al., 2011).
- Assess - BIM administers sufficient support for assessing design decisions, depending on validated requirements (Tzortzopoulos et al., 2019; Soliman-Junior, Awwal, Tzortzopoulos, et al., 2022). It can be used to check if the design process of the product considered stakeholders' requirements to ensure value generation (Baldauf et al., 2020).

Requirements management plays a vital role in generating value for users. It is well known that BIM can support the modelling of client requirements (Baldauf et al., 2020). However, there is little evidence in the literature of adaptations needed for its use in the context of social housing upgrades.

RESEARCH METHOD

RESEARCH DESIGN

Design Science Research (DSR) was adopted in this investigation. The products of Design Science Research are (i) constructs; (ii) models; (iii) methods; and (iv)implementations (March & Smith, 1995). This investigation proposes a process model to manage client requirements in the social housing upgrading context (see Figure 2).

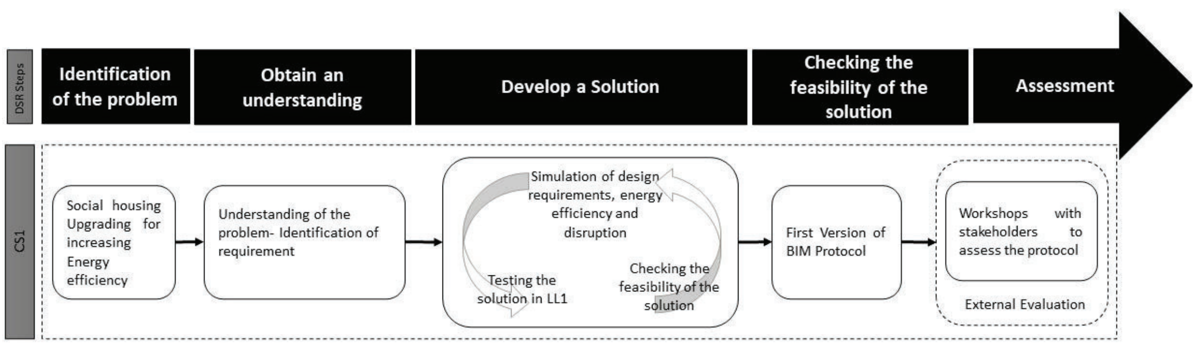

Figure 2: The Research Design

Each research phase consists of five steps based on (Kasanen et al., 1993)'s model : (i) identification of the problem; (ii) obtain an understanding; (iii) develop a solution; (iv) check the feasibility of the solution and (v) assessment.

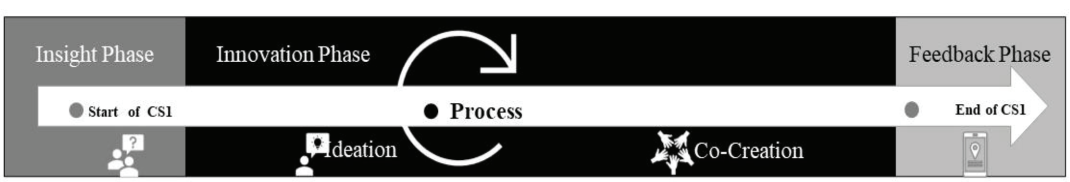

Figure 3: The Phases of the Case Study

The data was collected through the retrofit of 8 social housing dwellings in West Yorkshire, UK. Three workshops were developed to identify user needs and help reduce conflicts between stakeholders, supporting a participatory upgrading process (Keyson and Lockton, 2016). The workshops included: a. Insight; identification and capture of user's requirements; b. Innovation; consisting of ideation and co-creation; and c. Feedback; evaluation (see Figure 3), that follows an iterative process to foster collaboration (Tang & Hämäläinen, 2014).

The workshops were planned to involve the local council, architects, retrofit coordinator, construction company, and tenants/users of the social houses to be upgraded). However, only users and the local council were effectively engaged in the workshops. The council selected 8 houses for retrofit (See Figure 4), mainly aimed at improving their energy efficiency.

Figure 4: Before (left) and After(right) image of the social housing retrofit case study

The retrofit work is now completed (See Figure 4), and the following components were changed/implemented; (i) heat pumps were installed, gas boilers and cookers were removed ending reliance on fossil fuel; (ii) triple glazed windows, loft insulation, cavity wall insulation and external wall insulation were provided, (iii) new roofs were fitted and chimneys closed to remove a possible cold bridge; (iv) Photovoltaic panels and solar thermal panels were installed to create renewable solar energy (v) new entrance doors installed, new bins stall and backyard fences are installed. Figure 5 depicts the timeline of the case studied.

Figure 5: Timeline of the case study

The empirical data was collected from 11 interviews, which included 5 residents from the selected upgrading project and 6 residents from the wider estate. The interview protocol consisted of (i) residents' satisfaction with their homes; (ii) Laddering (what are the three most important things to be upgraded in the house and why); (iii) profile of the residents.

Workshops (see Table 1) were facilitated to capture requirements and to evaluate design versus users' needs. The 1st workshop included four members of the council and four researchers, targeting to better understand how different tools help capture user requirements and help increase end-user participation in the upgrading project. The 2nd and 3rd workshops included three end-users and four researchers, aiming to further understand requirements and experiment with the use of digital models.

Table 1: Sources of Evidence

Source of Evidence	Stakeholders	BIM-Based Tool	Occurrence
Workshop 1 Testing tools to understand requirements and values	• Four Council Members Four Researchers	• BIM: Exiting model, value cards& evaluation of tools	Developed- 11 Jan 2022
Workshops 2 & 3 (i) Testing requirements through BIM immersive experience (ii)Design vs Values	• Four End Users (Tenant) Four Researchers	• BIM: Existing Model & developed design model, value cards and evaluation tools	Developed- 21 Feb 2022

RESULTS

Table 2 presents some interview results, including the highest dissatisfaction elements identified in the existing houses. These indicate focal elements for consideration as part of the upgrade of the houses. Unfortunately, not all requirements were considered in the upgrading process by the council due to financial constraints.

Table 2: Dissatisfaction with product attribute

Key Criteria	Product Attributes	Dissatisfaction Rate
• Dimension and space layouts	• Dining space, Kitchen, Storage	High
• Materials, finishes, equipment	• Doors, windows, wall cladding	Very High
• Acoustics, temperature, privacy	• Winter temperature, privacy, noise	Very High
• Env.quality, safety, accessibility	• Accessibility for the elderly	High
• Consumption, maintenance	• Energy costs/ utility costs, heating system performance	Very High

During the workshops, BIM models were used for (i) Real-time rendering linked to BIM; (ii) BIM models used in a 3-sided Immersive Cave. BIM models of the houses as existing, and the newly designed solution were developed and displayed in the workshops (see Figure 6). Examples of alternative solutions (e.g., colours of windows, fencing materials etc, scaffolding construction) were explored. The tools developed assisted in eliciting user requirements. The tools can, in the future, be used to support generating design options and evaluation through visualisation.

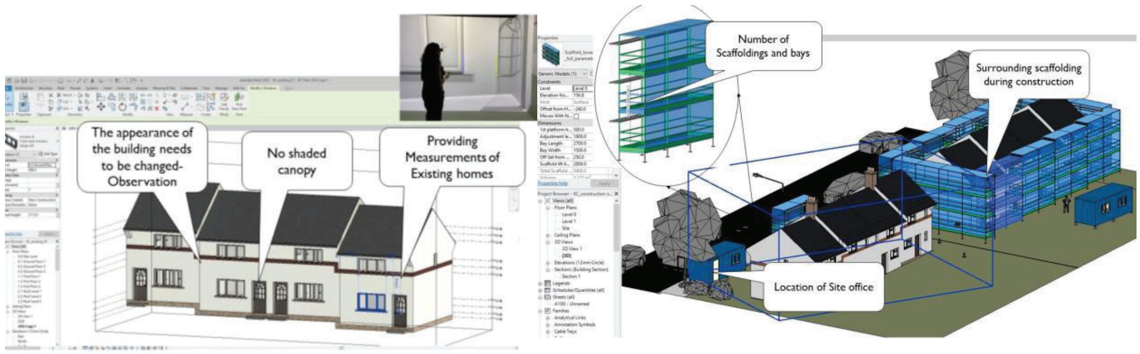

Figure 6: The BIM Model developed in the CS1

The BIM tools foster communication and collaboration by considering multiple stakeholders' needs, aiming to reduce conflicts and misinterpretations, and supporting improved value generation.

THE PROCESS MODEL

The proposed model adopts the stages presented in Baldauf et al. (2021) requirement management model, including the steps displayed in Figure 1. The process consists of sequential and iterative stages. Figure 6 shows the process model to manage user requirements with BIM in social housing upgrading projects.

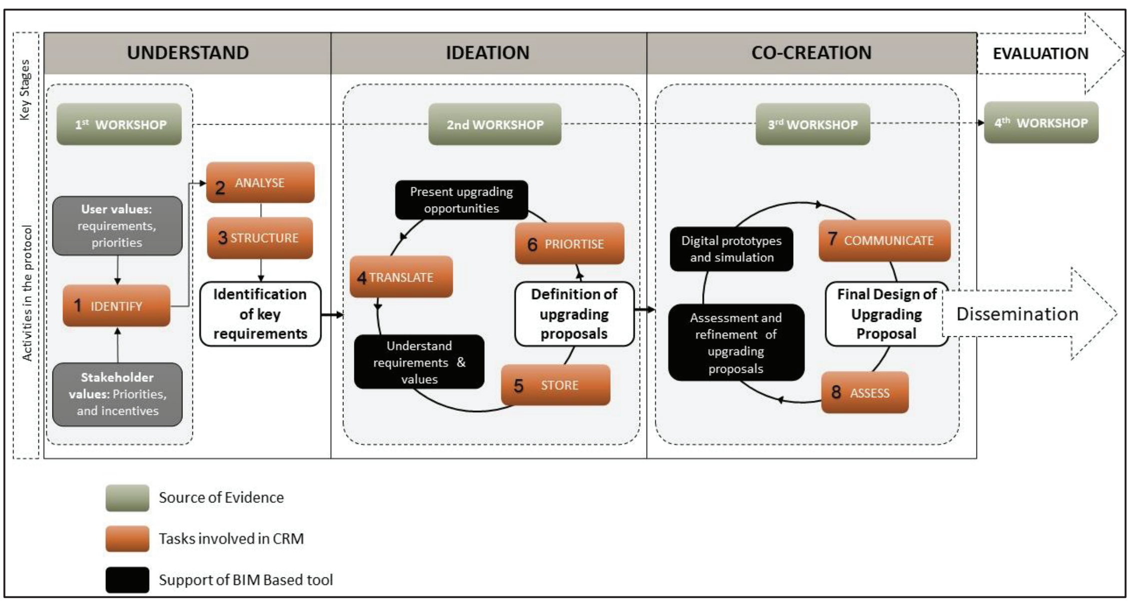

Figure 7: User's requirements management process model for social housing retrofits

The process starts with the identification of stakeholders and their priorities, which need to be analysed and structured in the next phase. The structured requirements need to be embedded in design solutions, and connected in BIM to architectural elements such as building spaces, the colour of the fence etc. BIM (e.g., Autodesk Revit) enables the required data to be stored and reused.

Design alternatives for the upgrade project should be presented visually (through diverse BIM models, i.e., one per alternative to be discussed) and shown to stakeholders. Such joint discussions should enable any conflicting requirements to be identified, and joint decision-making to happen. All information should be accessible to multiple stakeholders at various stages of the design process.

BIM-enabled experimentation through immersive environments, digital prototyping and animation/video rendering allows end-users to directly participate in the design process, which will support the generation of user value in the upgrading process. The last phase involves an evaluation of the process. The main steps are further detailed as follows.

Step 1-Identify: commences with the identification of stakeholders and capturing requirements. These priorities will be based on the purpose of the upgrading project (e.g., energy efficiency upgrading). In the case studied, the initial requirements were limited to energy efficiency, without further consideration of other users' requirements. Hence, mostly product attributes were considered (e.g., energy efficiency, installation of heat pumps), rather than connecting the project users' needs.

Step 2-Analyse: In the analysis phase, multiple sources of information should be considered for capturing and eliciting requirements. For instance, in this investigation, different stakeholders, such as councillors, retrofit co-ordinator, council members, design and construction team and tenants were interviewed. As there are boundaries regarding cost and construction issues, not all initial requirements may be implemented in the upgrade. It is important that these are prioritised accordingly, with input from all stakeholders.

Step 3-Structure: This is based on organising the collected requirements. This can also be based on existing taxonomies (e.g., Baldauf 2020's structure). Structuring the requirements will support the translation of the requirements into design solutions.

Step 4-Translate: Step 4 focuses on translating the requirements into design solutions. For instance, the initial requirements can now be connected to a digital model and presented to the stakeholders.

Step 5-Store: Requirements must be stored in BIM software and can be available to the main stakeholders. For instance, the information stored in the digital model in this investigation has been reused for eliciting client requirements in multiple workshops and meetings.

Step 6-Prioritise: BIM - can support prioritisation through the digital model. These are communicated to the stakeholders through virtual reality and real-time rendering. There are multiple stakeholders in social housing upgrading (e.g., tenants, council members, design, and construction team, retrofit coordinator etc) and their needs need to be considered.

Step 7-Communicate: Communication improves through the use of BIM. During the workshops, users pointed out that the digital models and real-time rendering enabled a much better understanding of the user of changes to be implemented in their homes and enable space for discussions on what would be most appropriate to be implemented, from the users' perspective. As discussed in (Soliman-Junior, Awwal, Tzortzopoulos, et al., 2022), the interviews also reported that BIM-based requirement models would support an improved understanding of the project.

Step 8-Assess: the requirements management process needs to be assessed at the end of the upgrade, so improvements can be implemented in next projects.

The above process aims to provide a better approach to facilitate the design of social housing upgrading projects and enable collaboration to manage requirements.

CLOSING REMARKS

Requirement management explores solutions for managing stakeholders' requirements in construction projects (Jallow et al., 2014). This research highlights the importance of requirement management in social housing upgrading. The discussion highlights that the adoption of the proposed process model can improve the generation of value and the ability of social housing users to co-create design solutions for the upgrade of their homes. End users and stakeholders (council, construction companies, architectural enterprise) are fundamental actors and their requirements should be key drivers in the design and delivery of upgrading solutions (Soliman-Junior et al., 2021).

The process model allows communication through visual management, iteration, and opportunities for feedback in the phases. A summary of how the process model addresses lean principles is presented in Table 3. The findings presented in Table 3 are consistent with some early synergies identified between Living Labs and Lean in (Soliman-Junior et al., 2021)'s paper.

Table 3: Lean principles and CRM Process Model in Social housing upgrading

Lean Principle (Koskela, 1993)	Process Model
Increase Value	• Requirement management focuses on early stakeholder collaboration, that generates value. • Participatory approaches are practised through ideation and co-creation. • The process model aims to support collective decision-making.
Increase process transparency	• Use of BIM to increase transparency and collaboration among stakeholders.
Use visual management	• Using BIM potentially allows for a real-time change in the models, and can be part of visual management processes.
Continuous improvement	• The process is iterative and allows for assessment and refinements in the design process.
Reduce cycle times	• The process allows accelerated feedback loops, minimising errors and thus contributing to the reduction of cycle times.

There are some limitations to this investigation. The artefact suggested (requirements management process model) was developed based on a single and relatively small empirical study. It should also be highlighted that only the researchers developed the BIM models and applied them in the case study to capture and elicit user requirements. This method is not thoroughly applied and tested in another case study; further research is needed to assess the applicability of the artefact. The scope of product attributes to be upgraded was limited due to cost and the council's suggestions. Further empirical data is needed to generalise the artefact's applicability to other upgrading projects.

Despite the limitations, the contribution of this investigation is the introduction of the steps such as identifying and capturing the requirements of end-users, structuring the digital model, storing information, and accessing them at different stages of the project to avoid conflict, and the use of the BIM-based tools in the process to increase collaboration among stakeholders. Also, lean construction practices as described in Table 3 could be further enhanced by using the process model in social housing upgrading. These provide the opportunity to improve understanding of requirements at multiple stages (e.g., preliminary design, development, and construction phase) of the upgrading process, enabling problems to be addressed transparently and facilitating better communication among multiple stakeholders.

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