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Social Housing Retrofit Living Lab: Methodological Approach

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Abstract. Social Housing Retrofit offers positive social, financial and health improvements for low-income populations. However, the stakeholders in such projects might have conflicting needs and interests, thus hampering the retrofitting process. Living labs can play a vital role in supporting mediation amongst stakeholders and thus help alleviate such challenges. Living Labs (LLs) are user-centred initiatives for the development of innovative solutions in real-life contexts through a collaborative process. User involvement is vital in the LLs' innovation process. This paper describes the setup of a Social Housing Retrofit LL from a methodological perspective. Existing literature reporting LLs often lacks clarity on its description of the LLs underlying methodological approach. The main contribution of the paper is to depict the living lab as a method based on the social housing retrofit context. The proposed solution i.e., the LL methodological approach, is described at a detailed level, including its main activities, and expected outcomes. The approach can bring together residents and other stakeholders, leveraging knowledge sharing, collaboration, and co-creation through their involvement in the retrofit process. The solution is evaluated in contrast to existing literature, and it should be implemented in the future throughout the development of an ongoing research project U-VITAL.

1. Introduction

Social Housing Retrofit is one of the pressing needs for achieving a sustainable climate. Social housing retrofit will improve the living conditions of low-income households, reinforcing psychological feelings of belonging and contributing to social stability [1-3],. The human-centred design offers the possibility of improved success in developing products [4, p- 136]. Hence, user involvement in the design process is seen as essential to enabling successful outcomes [5,6]. However, in social housing programs, there are conflicting interests between the stakeholders and user value generation is often ignored [7] in the process. As a result, there is a lack of consideration for users' needs, poor collaboration between the stakeholders and focus on quick solutions that can cause problems in the longer run[8].

To provide more effective bridging strategies, there is an ongoing collaborative research project, U-Vital: 'User-Valued Innovation for Social Housing Upgrading through Trans-Atlantic Living Labs',

amongst research institutions in Germany, Brazil, the Netherlands, and the UK. The mutual exchange of experience will provide a comprehensive understanding of social housing retrofit on a global level. It will explore LLs, a user-valued innovation to support decision-making and collaboration in retrofit projects.

This paper stems from the U-Vital research (https://research.hud.ac.uk/institutes-centres/idl/currentresearchprojects/uvital/) and the aims of the paper are to establish living lab as a methodological approach in social housing retrofit, and to discuss the method at a detailed level, including its main activities and their expected outcomes.

2. Living Lab as a method

This segment discusses the living lab from a theoretical perspective.

2.1. Understanding of the Living Lab

Living labs are user-centred initiatives [9] and social innovations that allow value chain actors at the centre of the process [10]. They foster communication and collaboration, use participatory approaches, focus on user's needs and values, and include stakeholders in the decision-making process [11]. The term LL was first introduced in the early 1990s [12,13] in a real-life context at MIT's media lab [13-15]. Afterwards, LLs have been used in various domains, such as energy, mobility, healthcare, urban design, and housing [16] The LL approach helps the stakeholders involved in the process by delivering resources to generate "real-world solutions" [9,10,12]. As solutions are created, examined, and validated in multi-contextual and real environments [17], LLs foster bottom-up communication and collaboration between stakeholders [11].

2.2. Living Labs in practice

The variety of definitions e.g., method [14] tool [18], environment [13], sessions [19], ecosystem [20]; indicates a lack of conceptual clarity regarding the understanding of LLs [21]. Living Labs can be used as a methodology [11], including three stages: a. Exploration: Getting to know the existing situation and designing possible future states; b. Experimentation: Real-life testing of one or more future states; c. Evaluation: Assessment of the impact of the experiment with regards to the current situation to iterate the future state [22]. Living labs are described as a linear or non-linear process, using standardised or customised tools [15]. Tang and Hämäläinen (2014) [11] synthesized LL processes in a four-stage iterative model: (1) requirements; (2) co-design; (3) prototyping; and (4) test and tracking. Living lab is a collaboration between public actors, private actors, users, and knowledge institutes. The development process of the LLs is iterative, which will be alternatively used and evaluated by the end-user and feedback will be used to further develop the key design requirements of retrofit [22].

Table 1 demonstrates a practical case of LL. The key to encouraging social innovation is to focus on the betterment of collaboration and participation [23], especially when it comes to achieving social transformation. The following Table illustrates the use of technological initiative to solve participatory dilemmas and generate citizen interaction. The aim of the LL is to support innovation in local associations, and the rationale is to give them the option to promote, develop, test and experiment with technological initiatives and solution [12].

The Turin Living lab was formulated to support innovation in local enterprises and associations. The main rationale was to allow these entities 'to promote, develop, test, and experiment with technological initiatives and solutions. The Lab falls into the more general Smart City Strategy of the Municipality of Turin aimed at developing a model of urban development based on the promotion of environmental and social sustainability. In some projects, products were made available in the neighbourhood, like e-bikes, bike locking systems, or apps for tourism. Some projects ran the test by the municipality such as street vacuum cleaners or monitor polluters. And finally, the lab involved citizens directly in co-producing services using a crowdsourcing approach (such as improving apps, collecting environmental data through low cots carrying sensors which

uploaded data to a central server, maintaining historical and public drinking fountains, carpooling services, etc.) The implementation was successful, and the results were positive. The living lab experimentation was successful to support innovation in the traditional procurement models, where citizens (5% of the population of the district) participated actively [12].

Table 1: Descriptive example of Turin LL

The active participation was launched by submitting residents' ideas with smart strategy and general goals of the municipality. The main benefit of the LL was the experimentation of an innovative solution that supports innovation associated with traditional public procurement models [12]. It is observed from Table 1 that, LL focus on identifying end-users' needs and societal problems, so solutions can be collectively designed, prototyped, validated, and refined in real-life contexts [Westerlund and Leminen, 2011 apud 12]. They support stakeholders to fully address user's needs [10] and rely on collaborating end-users and stakeholders directly together in LL activities [24], thus playing a co-creation role [11].

2.3. Relationship between Living Lab and Co-creation

"Living labs are user-centred sessions focusing on co-creating meaning with the participants, exploring scenarios and evaluating propositions" -(Papadonikolaki et al. 2019, p. 385)[19]. Co-creation refers to new domains of collective creativity and can provide positive consequences if applied in the early stages of the design development process [25]. In the development process, co-creative approaches are found among the users, researchers, and stakeholders LL is an innovation platform to imply a user-driven approach [10,17], where the concept can be used as a tool, a methodical approach, a progress model or a man-made environment to test a long-term project or program, which can generate co-creation between the users and stakeholders [17].

3. Research Design

The methodology adopted in this paper is the systematic literature review to present the understanding of the concept of LL and how the LLs are applied in a real-life context to support innovation for active participation. The following section will describe the proposed methodical approach for a living lab aiming to understand LL as a methodological approach when applied in social housing retrofit.

3.1. Description of the proposed LL Methodological Approach

To manage conflicts between the stakeholders, the living lab will be applied as a method in social housing retrofit, as they allow a systematic innovation to improve the participatory process [26]. This section will discuss a subsequent living lab in an SH Retrofit project in the UK. The case study is situated in West Yorkshire, aiming to deliver 100 retrofit projects, initially starting with 8 dwellings as a pilot project.

The idea is to use the concept of LLs aiming to apply process innovation by using preferred visualisation approaches during the planning and design processes of selected cases of SH upgrading projects. The living lab method will introduce specific boundary objects to facilitate collective efforts through raised equality between participants [27]. A boundary object is a communication process [28,29], which overcomes technological and societal barriers [19]. It is a practice-based approach to transfer the knowledge among the stakeholders [30], to be used in a user-centred LL setting [14].

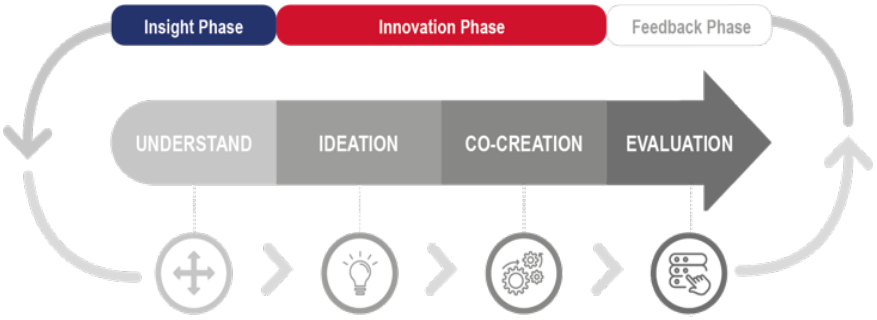

Figure 1: The phases of Living lab setup

The phases of the living lab (refer to Fig 1) have been developed from the underpinning literature [11,22]. The setup of a living lab is divided into three main phases: a. Insight; Understanding of stakeholder's requirements and values b. Innovation; consisting of two steps, ideation and co-creation c. Feedback; evaluation stages in a living lab (refer to Fig 1), following an iterative process to allow collaboration and foster communication.

3.2. The setup of the Living Lab

The proposed Living Lab process is summarised in Figure 2, highlighting the process, the involvement with users and stakeholders, and the boundary objects in the process to foster participation and collaboration and mediate effective bridging strategies. The concept of boundary object was introduced by [31].

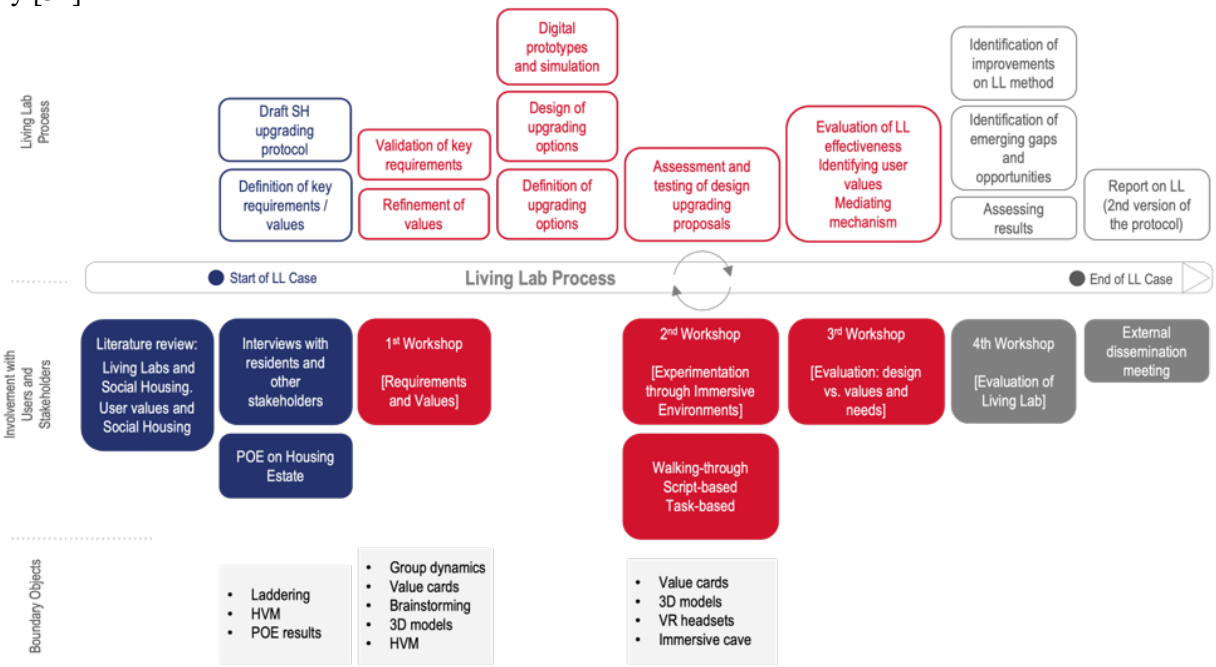

Figure 2: The living lab process

The living lab will propose four planned workshops in sequence to achieve the purpose of understanding users' requirements and values, experimenting through an immersive environment, evaluating design versus users' values and needs, and evaluating the Living Lab. The detailed plan for Living Labs includes all activities that are needed to support this process from the start to the end of the case and such activities include interviews and the development of BIM models. The process is iterative,

allowing refinements in the method, while implementing in different projects, which is a similar understanding to Malmberg et al. [22], Tang and Hämäläinen [11] and Leminen [10]'s paper.

3.2.1 The Insight Phase (Understanding of the process). This phase (refer to Figure 2 and 3) starts with exploring existing literature by conducting a systematic literature review on social housing retrofit, the connection between LL and SH to effectively mediate among stakeholders, and how user value can foster communication and resolve conflicting understanding of problems and needs of stakeholders. The initial phase will develop a series of interviews for the stakeholders (e.g., Council/ Housing Association, Architectural team, construction companies, retrofit co-ordinator etc). The research problem will be explored from the qualitative data from interviews and observations. Qualitative data are impressed due to resolving complex social issues and conflicting interests between stakeholders. Semi-structured interview protocols will be developed to create an in-depth understanding of key stakeholders. Key project stakeholders shall be interviewed either remotely or in person, whereas residents shall be interviewed in person. After the interviews are conducted, the analysis and identification stage will commence in parallel to the ongoing activities. The boundary objects at this stage are hierarchical value map (HVM), laddering, and post-occupancy evaluation (POE) results. This stage will include coding of interviews using N-Vivo, laddering, and the development of a hierarchical value map (HVM), thus contributing to defining the key requirements and identification of alternative design solutions based on these requirements. The strategies of the energy retrofit, structural aesthetic retrofit, and social value will contribute to preparing the draft social housing upgrading protocol.

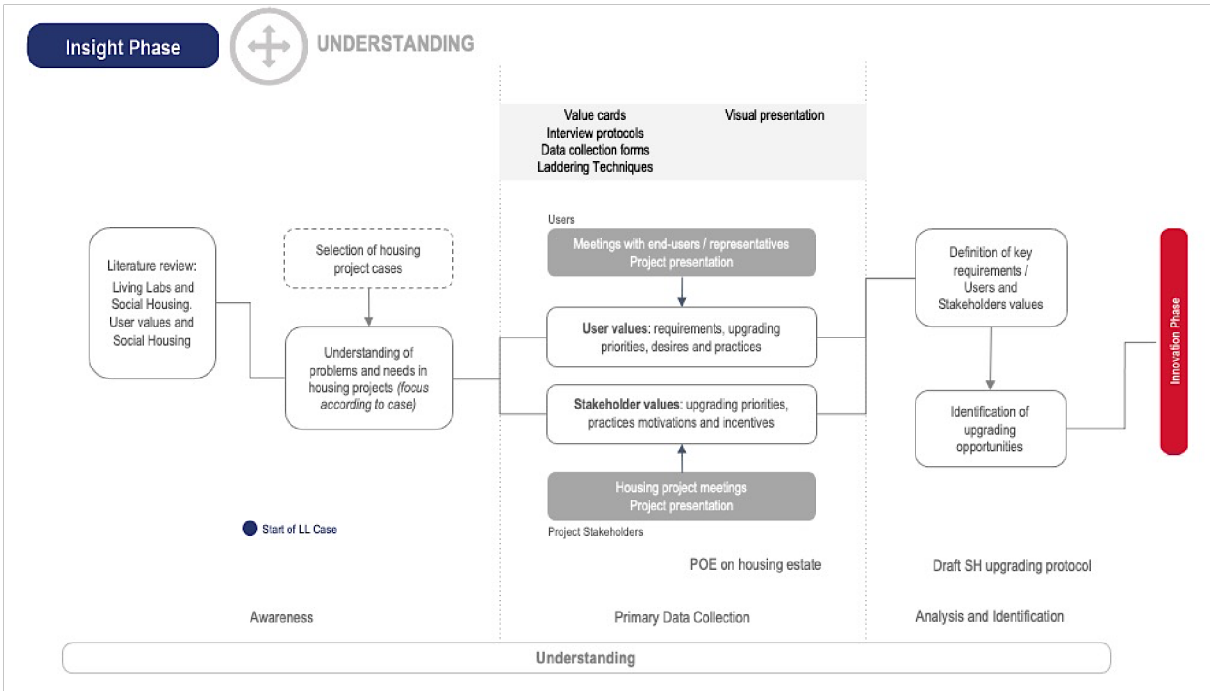

Figure 3: The insight phase in the LL Process

3.2.2 The Innovation Phase. This phase (refer to Figure 4) consists of two steps: a. ideation, b. co-creation. The Innovation Phase. The four workshops that will take place at the University of Huddersfield Phidias Lab and will consist of an opportunity to use different approaches and BOs to capture users' and stakeholders' values will start at the innovation phase. The boundary objects at the ideation phase are group dynamics, value cards, brainstorming, 3D models and a hierarchical value map (HVM). The value cards will be developed to rate the degree of importance of each value against other cards identifying the design requirements. The development and refinement of the value cards will be

needed for an understanding of key design requirements. The laddering questions will be analysed to generate an in-depth data processing technique to understand how attributes of products are translated by consumers into value-related associations, effectively supporting the generation of hierarchical value maps (HVMs) [32]. The identification of evaluation criteria for validation of the HVM will contribute to defining the upgrading proposals.

(i) The ideation phase- The next phase will organize the living lab workshop 1, at the initial stage of the ideation, to identify the requirements and values of users. The ideation stages help channel identified requirements of users to a structured solution with the aim of achieving a better solution through prototyping and user testing [33]. The various stakeholders of the housing project and the users will be participants in the workshop. To mediate amongst the stakeholders, the visualization of concept is primary in the design briefing process as BIM can act as a potential in the design process to increase efficiency in the building industry specialists [34]. The existing Building Information Model (BIM) will be developed as a basis for the retrofit model, which will be used for simulation and visualisation purposes during the Living Lab sessions as boundary objects to validate upgrading opportunities. BIM represents the process of development and use of a computer-generated model to simulate the planning, design, construction, and operation of a facility [35]. BIM can be obtained as a "shared digital representation of physical and functional characteristics of any built object" [36].

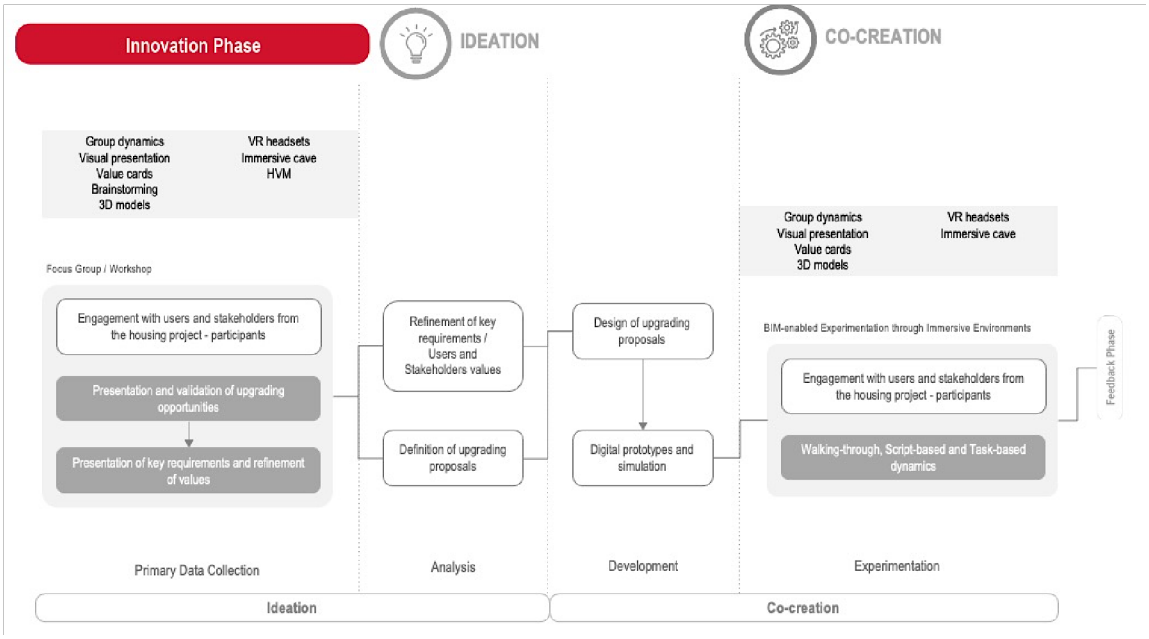

Figure 4: The Innovation (Ideation and Co-Creation) Phase in the LL process

(ii) The co-creation phase- This phase (Refer to Figure 4 and 5) consists of the development of design proposals and BIM-enabled experimentation through immersive environments. The value cards at this phase are value cards, 3D Models, AR (Augmented Reality) VR Headset, and Immersive Cave. AR is a visualization technique that provides a real-life setting by dealing with the combination of real-world and computer-generated data [37]. The technical designed model will be developed using BIM (Building information modelling) and simulation (e.g., Thermal analysis, lighting analysis etc.) will be conducted. The 2nd workshop will commence for the stakeholders to experience the immersive environment in the Phidias Lab at the University of Huddersfield. This is an iterative stage which will feed into the refinement of design proposals. This stage will host the 3rd workshop to understand the design proposal vs. values and needs, and to evaluate the effectiveness of LL identifying user value mediation mechanism. The analysis will feed into the final design requirements following an iterative process.

3.2.3 The Evaluation Phase (Feedback). The last phase (refer to Fig 2 and 5) will be marked as the end of the living lab, which will be used for validation and testing to check the effectiveness of the LL. The evaluation of the effectiveness of the living lab by checking the user value and mediating mechanism (e.g., Value cards, HVM, laddering, BIM etc.) will be derived. The 4th and last workshop will be focused on the identification of lessons learned, emerging gaps and opportunities for improvements in living lab methods. It will be conducted for the collective reflective analysis of results derived from previous workshops (which were based on understanding users' requirements and values, experimenting through an immersive environment, and evaluating design versus values and needs). The feedback phase will merge into the dissemination of the case by providing reports on LL contributing to the final design proposal for retrofit

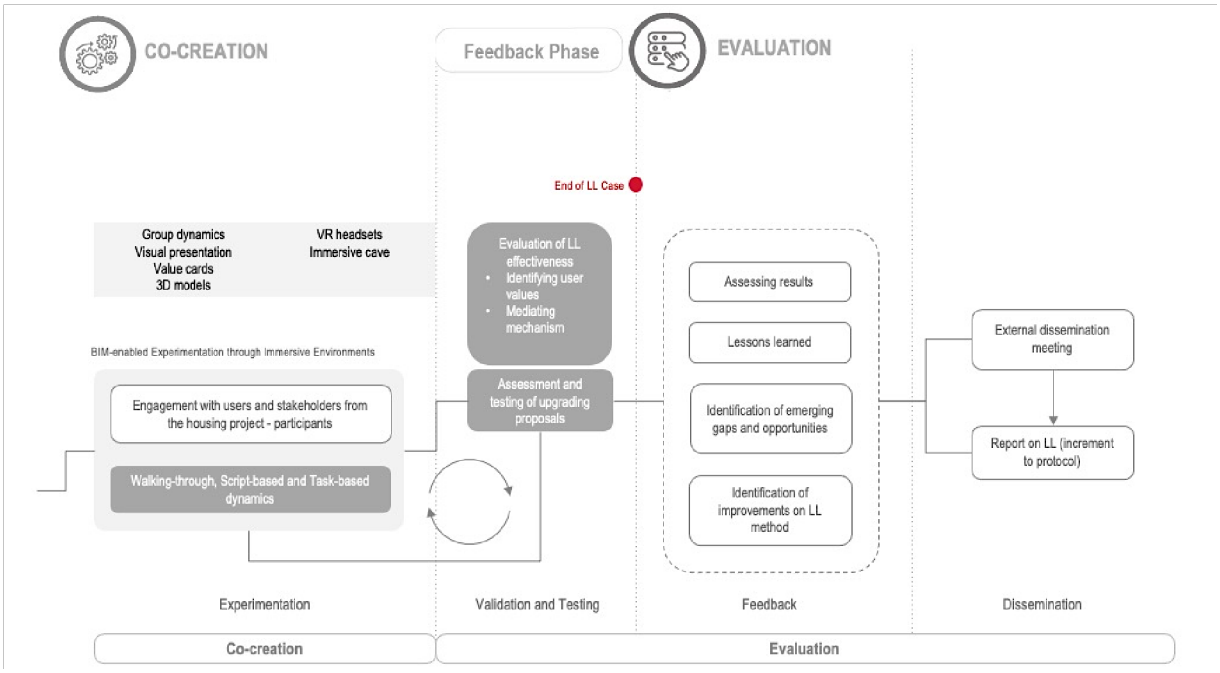

Figure 5: The Feedback Phase in the LL process

4. Findings and discussion

The living lab is a social and dynamic environment facilitating stakeholders to better connect and collaborate toward an innovation [21]. LL is an iterative process [11,15] allowing opportunities to involve users in the retrofit process. The above discussion depicts a four-staged iterative model following Tang and Hämäläinen, 2014's [11] synthesized LL model. The ontological assumption from the literature on LL suggests a lack of clarity to understand its concept [21], providing an overview of research gap in the area.

The above discussion depicts an overarching methodology of the living lab in a social housing retrofit project, contributing directly to the research gap. The process is directly connected to the literature review as it is observed that the living lab process is arranged in three major stages; a. understanding the problem (Exploration) b. innovation to ideate and co-create solutions (Experimentation) and feedback to evaluate the solution (Evaluation) [11,22].

The ongoing living lab in the UK is at the ideation stage of the proposed method. The covid-19 pandemic has increased difficulties at the initial data collection level of the project; however, video conferencing methods and technologies have been used to conduct online interviews enabling

participation. Residents from 6 out of the 8 terraced buildings to be retrofitted agreed to be interviewed in which 3 face-to-face interviews has been conducted at the ideation stage. The initial BIM Model and value cards have been developed to conduct the first workshop.

The research tools (e.g., interviews, workshops, focus groups) used in the method will have major importance in mediating stakeholders in SH retrofit projects. The research project will explore interviews, laddering, HVM (hierarchical value maps) and POE results as a research tool in the insight phase to understand the research problem. Qualitative aspects of the interviews are emphasized as the project will deal with multiple conflicting problems. Interviews with the stakeholders will play a major role in the development of a living lab as a method. A semi-structured interview protocol helps to understand the residents' satisfaction with their dwellings and to capture their values. A similar interview protocol (including the laddering questions) shall be used in the future to interview residents from the broader housing estate, aiming to provide a more comprehensive analysis of users' values within this local context.

In the next stage, the research will use BIM (Building Information Modelling), value cards, VR Headsets and Immersive cave to co-create solutions. Considering the research project aims, the potential value maps (BO) can be understood as key elements to explicitly promote a discussion around users' values to support the Living Labs Communication through graphic representation will act as a key driver in the methodical approach. Table 1 depicts the importance of technological artefacts in a living lab. New technological communication methods such as Augmented Reality (AR), Virtual Reality (VR) and Building Information Modelling (BIM) will support mediation amongst the stakeholders, especially end-users to support better communication and stimulate creative design solutions. The initial model has been developed and it will also be used to represent the retrofit design and shall support the development of a BIM-based energy simulation and analysis as well as the use of immersive technologies (such as Virtual Reality) during the Living Lab sessions. The last phase will evaluate the living lab in social housing retrofit, following external dissemination.

5. Conclusion

As the living lab can be perceived as a social, context-dependent, and dynamic co-create solution, where the users and stakeholders are enabled to communicate better and collaborate toward an innovation [21], the living lab can be applied to foster the decision-making process. The findings of the paper are suggestive of using a living lab as a method to solve barriers, in social housing upgradings such as providing an innovative solution that is inclusive of users and other stakeholders in the upgrading process and mediating conflicts among stakeholders. The method needs to be examined through implementation further for dissemination. The knowledge-sharing process in the Living Lab process described will enable co-creation and collaboration in the project. However, it might face challenges in the implementation stages such as ethical concerns, lack of interest etc. But the boundary objects used in the living lab method will foster collaboration between users and other stakeholders, thus implementing user value in social housing retrofitting design.

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