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# A Methodology for Assessing the Impact of Living Labs on Urban Design: The Case of the Furnish Project

Inés Aquilué <sup>1,2,†</sup>, Angélica Caicedo <sup>1,3,\*,†</sup>, Joan Moreno <sup>2</sup> , Miquel Estrada <sup>4</sup>  and Laia Pagès <sup>1</sup>

<sup>1</sup> CARNET, Technology Center UPC, 08034 Barcelona, Spain; ines.aquilue@upc.edu (I.A.); laia.pages@carnetbarcelona.com (L.P.)

<sup>2</sup> Department of Urban and Regional Planning, Universitat Politècnica de Catalunya (UPC), 08034 Barcelona, Spain; joan.moreno@upc.edu

<sup>3</sup> University Research Institute for Sustainability Science and Technology (IS.UPC), Universitat Politècnica de Catalunya (UPC), 08034 Barcelona, Spain

<sup>4</sup> Department of Civil and Environmental Engineering, Universitat Politècnica de Catalunya (UPC), 08034 Barcelona, Spain; miquel.estrada@upc.edu

\* Correspondence: angelica.caicedo@carnetbarcelona.com

† The first two authors contributed equally to this work.

**Abstract:** This paper presents a framework to support the assessment of urban design projects through Urban Living Labs (ULLs). The framework is based on the Tactical Urbanism (TU) practices and involves the use of Mobile Urban Elements (MUE) in uncertain and potentially confusing conditions (e.g., the COVID-19 context). The methodology includes the application of the Four-Phase Model (problem and ideation; development; implementation, testing and assessment; final proposal) and a quantitative and qualitative assessment. The proposed assessment criteria were developed through an evaluation according to three aspects: (1) feasibility impact; (2) social impact; and (3) spatial impact. The methodology was applied to Furnish, an urban design project based on a ULL and prototyping, which was recently developed in five European cities. The empirical results, obtained using the impact analysis, indicate that the prototypes developed in the project are transferable to other cities and generate social interaction in public spaces. The applied research showed that the Four-Phase Model may be used as a new and improved iterative design process: the LOOP Scheme. The application of this assessment methodology to ULLs may provide valuable information for the future planning of urban interventions in public spaces.

**Keywords:** urban living labs; impact analysis; urban design; co-creation; mobile urban elements; prototyping



**Citation:** Aquilué, I.; Caicedo, A.; Moreno, J.; Estrada, M.; Pagès, L. A Methodology for Assessing the Impact of Living Labs on Urban Design: The Case of the Furnish Project. *Sustainability* **2021**, *13*, 4562. <https://doi.org/10.3390/su13084562>

Academic Editors: Kenji Doi and Alexis M. Fillone

Received: 15 March 2021

Accepted: 15 April 2021

Published: 20 April 2021

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## 1. Introduction

In recent years, the design of urban elements in public spaces has deeply evolved, and citizens have become active and empowered agents in transforming urban environments [1–3]. Tactical Urbanism (TU) has gained a relevant role as a testing strategy and has also been frequently deployed by public administrations, communities, and civil society in uncertain and controversial circumstances that require rapid responses [4]. Many of the challenges cities face are unpredictable due to their evolving and complex nature, and events such as pandemics, natural disasters, and conflicts make urban systems even more unstable. In this context, tools such as prototyping, TU strategies, and experimental projects seem to be suitable for developing testing solutions to tackle these unexpected, although common, challenges in urban environments [4]. In particular, experimental urban projects, such as Urban Living Labs (ULL), are suitable environments for developing innovative, technological, and rapid solutions due to the fact that ULLs aim to create urban design solutions capable of providing satisfactory responses to the needs of the different realities of built-up environments. The analysis of the potential impacts of ULLs based on TU practices using

Mobile Urban Elements (MUEs)—prototypes—in uncertain and potentially confusing conditions, such as the COVID-19 pandemic, might be beneficial for completing the increasing literature on ULLs, considering that their impact on urban design is still controversial and has not been clearly methodologically addressed [5].

Therefore, our aim is to propose and evaluate a well-structured methodology to assess the design process of urban elements for public spaces through ULLs in uncertain conditions. This methodology has been designed as a critical overview of previous urban design projects based on ULL environments [6–9] to assess the future prototyping of urban design projects. This paper presents a specific model for the development of prototypes within ULLs in uncertain conditions, and it displays a purpose-built impact assessment methodology that provides insights into the relevance of co-creation processes and users' engagement in urban design prototyping to achieve safe, efficient, inclusive, and friendly public spaces.

To prove its efficacy, the entire methodology has been applied to one specific case study: *Furnish*, which is a project for the design and fabrication of MUEs in new public spaces during the COVID-19 pandemic. The new constructed methods are applied to this project, the results are discussed, and the assessment is evaluated. The use of *Furnish* as a particular case study allows for a reiteration of the key role that actors involved in ULL projects play in design processes. To this end, the development of the *Furnish* ULL under a Four-Phase Model is proposed, with an assessment process in three main impact areas: feasibility, social impact, and spatial impact. Thanks to the proposed assessment, this research fills an existing gap in the literature, as it combines both quantitative—ex-ante and ex-post approaches—and qualitative data concerning the assessment of ULLs based on TU strategies, using MUEs in uncertain and potentially confusing conditions and giving a holistic perspective on urban design research. Using a case study, the validity of both the Four-Phase Model and the impact assessment are evaluated.

The evaluation of the Four-Phase Model and the assessment methods triggered a relevant discussion, and the findings of the research are focused on the appropriateness of the impact analysis and possible improvements of the Four-Phase Model. Furthermore, the strengths and weakness of the evaluated model are discussed, and the importance of considering the knowledge generated from the user's perspective is highlighted throughout the entire process. These new insights allow for the generation of a new model that includes an iterative co-creation process: the LOOP Scheme. The iterative nature of the LOOP Scheme can be evaluated in future research under less temporary conditions.

The methodological approach supported is presented in the paper through the following steps. Section 2 reviews the relevant literature concerning TU, ULLs, and impact analysis. Section 3 introduces the Four-Phase Model and describes the proposed impact assessment methodology. Section 4 details the case study and the application of the proposed assessment methodology. In this section, the results of the *Furnish* impact assessment are also presented. Section 5 presents the discussion, the contributions of the proposed approach to urban design and proposes the new model: the LOOP Scheme. Finally, the conclusions and main findings are provided in Section 6.

## 2. State of the Art

Due to the methodological nature of this paper, the relevant literature is mainly related to three experimental methods and strategies. Firstly, the proposed urban design assessment methodology is subjected to the principle of prototyping and the reclaiming of public space derived from tactical urbanism, especially under the conditions of the COVID-19 pandemic. Secondly, the assessed urban design process incorporates living labs as a framework of co-creation and testing in action. Thirdly, to foster our research the assessment of urban prototypes requires the use of impact analysis as a key method.

### 2.1. Tactical Urbanism Focused on Urban Mobility during the COVID-19 Pandemic

Theoretically, TU is framed within the Right to the City concept [10] and the production of social space, valuing both the physical or material sense of the urban environment in



which it is located and the symbolic sense, based on subjective perception and spatial experience. Thus, it should be considered that urban design does not by itself ensure urban activity or its usage by citizens, regardless of its compositional and urbanization quality. In other words, the urban vitality of a public space does not depend only on its spatial configuration, but on other aspects that play key roles, such as social and cultural contexts, and it should therefore be considered. In any case, not only is public space use an issue of land ownership, but civic appropriation by citizens and their active participation in its design are also factors that contribute to its vitality [11].

The health and social crisis caused by the COVID-19 pandemic impacted such things as the way citizens interact with each other in a context in which restrictive social distancing measures have been imposed and the physical configuration of public and private spaces in which this social interaction takes place [12]. A radical rethinking of living spaces to improve their livability, especially in compact urban environments, has forced a reflection on the design of common spaces. New strategies to reconsider the configuration and quality of housing projects and collective spaces, such as squares, parks, streets, and other public facilities, where socialization is unavoidable, have been established. In this sense, public administrations, like local and district councils, have strategically opted for temporary and low-cost actions at a local scale with a temporary nature, low cost, and high social impact through the use of TU strategies, which, before the pandemic, were carried out selectively. Therefore, TU is not an objective itself, but a process-oriented strategy to promote citizen empowerment and commitment to the design of shared spaces at a local scale in the short term and for a short time frame.

While TU is at an early theoretical stage, it has become an urban testing strategy that has been extensively employed by public administrations and urban planners in the last decade [4]. TU is a set of strategies and urban actions implemented in public spaces with a short-term nature, low-cost investment, and pragmatic nature in terms of final expectations. In terms of their scope, they are implemented at a micro-scale [13–15]. These actions were fostered during the COVID-19 pandemic in some European cities to generate public spaces for pedestrians [12]. On the other hand, TU values the social and organizational capital of urban communities [13]. TU strategies applied to urban design have traditionally been conceived as a collective trial for the execution of transformation operations that require a greater long-term investment. In this way, the city is conceived as a collective project [16] that reveals the will to involve the citizens as active agents in the design of public space and urban transformation processes [17,18], with a bottom-up approach [19]. The ‘bottom-up approach to urban planning’ generally means that local governments or committees formed by local citizens are responsible for urban planning in their districts, solving the urban problems and planning for future development [20].

The action strategies linked to TU are diverse and heterogeneous. These initiatives range from actions led by public administrations to particular initiatives of social communities or even individuals with different regulation levels [21]. The types of interventions depend on the actors involved in the process, as well as the physical context, which ranges from painted intersections to pop-up markets [13].

Action strategies related to tactical urban planning are linked to mobility space intervention. First, urban mobility space is public space and should therefore serve the general interest and not exclusively a mode or a social group. Some of the tactical urban planning actions are aimed at promoting active mobility (walking, bicycles, scooters, etc.) to reduce space allocated to private vehicles, whose negative externalities are highly recognized and which impact not only the environmental quality and the health of citizens, but also have a higher occupation of public spaces [22]. The transition from an urban model based on private vehicle use to a more sustainable one fosters compact and functionally diverse cities [23]. The development of urban walkability and cyclability necessarily involves the improvement of urban infrastructure related to these mobility modes, so that it ensures accessibility, safety, comfort, and efficiency. Tactical urban planning has proven to be cost-effective in promoting these types of urban mobility through tactical improvement actions, such as the renovation of road crossings or sections of streets [13].

In fact, TU strategies applied to urban design can be conceived as a collective trial [16] for the execution of transformational operations that require a greater long-term investment. It recognizes the key role that citizens play as active and empowered agents in public space design and urban transformation processes [18].

## 2.2. Urban Living Labs in Urban Design

Urban Living Labs (ULL) have become a trend in cities all over the world. In urban design, several city planners agree on the importance of understanding those for whom urban projects are designed [24], and it is here that ULLs find their niche, since their experimental nature recognizes the importance of user experience and co-creation [6,25–27]. However, their wide variety of forms and focuses makes it difficult for cities and citizens to comprehend what exactly ULLs are and how they can be set up. A considerable amount of literature has been published on ULLs in recent years, with the aim of establishing what living labs are [6,7,28–30]. However, a common definition of a ULL approach has not yet been established. Nevertheless, as the research on the topic is becoming more popular, several authors have agreed on some fundamental characteristics.

Starting from the term, Urban Living Labs is usually referred to as a wide variety of local experimental projects of a participatory nature that aim to develop and test innovative urban solutions in a real-life context [28,29,31,32]. In general, most authors conclude that ULLs are diverse and multidisciplinary spaces, where experimentation about innovative solutions is facilitated, with the heterogeneous presence of urban actors who can design, test, and learn from socio-technical developed innovations [24,28,31]. Likewise, the studies remark on the importance of actively engaging users who play a key role in ULL development [9,24,30,33–35]. Steen et al. established a definition of ULLs after scanning 90 place-based sustainable innovation projects in the Amsterdam area. The present study took the ULL characterization from their findings.

According to Steen et al., the living lab concept embraces an extensive range of activities and is regarded as an approach that involves actors in a process of co-creation, which potentially facilitates the construction of innovative values [6]. They defined four characteristics of ULLs (see Figure 1) [7]:

1. The goal: ULLs have to test innovative solutions, the knowledge developed has to be replicable, and the solutions have to increase urban sustainability.
2. The activities: ULLs have to permit the development of innovation, have to be in a co-creation environment, and an iteration of the activities has to be possible.
3. The participants: Users, private actors, public actors, and knowledge institutes become active contributors in the innovation and development process. All the involved parts must have decision power in the various stages of the innovation process.
4. The context: The living lab activities need to be enacted in a real-life use context.

‘Co-creation’ is a key element of ULLs, and not all so-called projects fulfil all the requirements in this regard. Steen et al. conclude that innovation projects can only be called living labs when they meet this key feature: users’ participation during their development [6]. Projects that focus only on researching, testing, implementing, or demonstrating a previously developed product in a real-life environment are often called living labs, but they are actually pilot projects, test sites, or innovation demonstrations. Nevertheless, it is easy to confuse these projects with ULLs, as many of them show a significant focus on user-related activities, carrying out user-oriented or user-sourced activities, but do not necessarily include users’ participation. ‘User-oriented’ activities are specifically intended to provide solutions from the users’ perspective, and ‘user-source’ indicates that project activities are performed using data actively or passively provided by the users. Relying on this evidence, this paper intends to remark on the importance that co-creation has in ULLs and the need for tools that could support its deployment.



**Figure 1.** The four characteristics of urban living labs based on Steen et al. definition [7].

In the case of urban elements designed to be placed in public spaces, the interaction with citizens is usually very intense, and an inappropriate design may therefore emerge rapidly during their use. ULLs constitute an opportunity to accelerate the interaction processes between urban elements and citizens/users, which draws on Sociotechnical Systems Theory, which creates an experimental proof to embody the social nature of urban elements as technology [5].

### 2.3. Impact Analysis through Living Labs

Each action has consequences, so when planning an initiative that will affect a social group and an environment, it is important that such planning considers both favorable and unfavorable consequences, the latter being generally unexpected. By focusing on unexpected implications, which are often negative, impact analysis can serve to identify potential consequences and help planners and designers make informed decisions [36].

The necessity for impact evaluation arises, because after a project's implementation, the expected impacts or benefits are not always generated, irrespective of the designing and planning process and how promising a project might appear. The information gathered from the impact analysis helps designers and planners understand what works, what does not, and how measured changes are attributable to a particular feature of the project [37]. According to Khandker et al., an effective impact evaluation should be able to precisely assess the features of beneficiaries' responses to the project [38]. Therefore, the benefits of a well-designed impact evaluation are long-term and support co-creation by integrating the beneficiaries [38].

Likewise, Ballon et al., after observing the difficulty of establishing a unanimous definition of living labs, decided to introduce a methodology for evaluating their impacts [5]. They also point out that the increase of studies that explore the notion of impact assessment and living labs in recent years have given a valuable description of the current 'as is' of living labs practice [28,39]. However, in agreement with Ståhlbröst, they stress the failure to determine the impact or added value that living lab projects generate [40]. Other authors

conclude that it is necessary to consider a series of concepts and issues to conduct an impact evaluation of ULL projects [5,24,40,41]. Ståhlbröst analyses several living lab projects and proposes five principles that should guide the impact analysis of living labs [40]:

1. Value: are living labs able to create value not just for the partners, but also for the customers and users?
2. Sustainability: do living labs take responsibility for the environmental, social, and economic effects they have?
3. Influence: understanding the degree to which users are encouraged and the influence they exert on the innovation and development processes that shape society;
4. Realism: setting realistic use situations and understand users' behavior in relation to understanding the degree of value for real markets of the generated results; and
5. Openness: establishing an adequate level of openness in the development of ideas, activities, and results to be able to cooperate and share in a multi-stakeholder milieu.

Ståhlbröst gives a wide description of how these principles are enacted in ULL projects. However, no analysis or guidance is given in terms of how to assess them [40]. For this reason, several studies have focused on filling this gap, advancing different conceptual tools, including a practical guide to measuring and managing impact [37], but none of them has established a logical process for assessing the impact of ULLs projects.

In this sense, this study establishes a framework for assessing the impact of ULL initiatives, recognizing the need for a logical process supporting the innovation development, as well as the actors' involvement and the role of communication in urban design. This proposed logical framework, based on the one proposed in *A Practical Guide to Measuring and Managing Impact* [37], establishes five steps for impact measurement, which are: (1) establishment of objectives; (2) stakeholder analysis; (3) measurement, verification, and evaluation of impact; (4) monitoring; and (5) reporting [37,42].

According to Hehenberger et al., the first step is considered to be the most important, as it involves the definition of the project objectives, so that the analysis focuses on the understanding of whether these objectives have been met after the implementation of the project or not [37]. The second step focuses on the identification of the different actors, which is a cornerstone of co-creation. The third aims to transform the objectives set in the first step into measurable results, considering the outputs, outcomes, impact, and indicators. In the fourth step, the measurement of the determined indicators is carried out through the systematic collection of data. In the last step, the organization presents information about the collected and analyzed data. This report is guided by the stakeholders' multiple objectives [37].

In this article, impact analysis is applied to assess urban design processes through ULLs. Therefore, next section describes the assessment methodology developed to evaluate the impact of ULLs in urban design, considering that design is a research process itself.

### 3. An Urban Living Lab Assessment Methodology: The Four-Phase Model and a Testing Process of Three Main Lines of Impact

The design process has not always been classified as a linear, iterative, and deductive solution. In the article, "How is design possible?", Hillier and Leaman argue that the rationality of design vindicated by famous figures, such as Le Corbusier, is in fact irrational, because the design is inconsistent with its past [43]. Indeed, in this respect, the authors defend design as an evolving process that needs to follow and comprehend its past to reach its future [43,44]. The approach inherent in research by design and learning by design claims the necessity for a clearer process to assess the appropriateness of solutions [25,45,46]. This perspective enacts research on socio-technical principles, which has shown that technology is not only composed of scientific and innovative developments, but also humanity and social aspects integrated into products.

According to Gregorowicz-Kipszak, the process of urban design generates a transversal product of social impact assessment [47]. In particular, the social impact assessment that frames the design of urban spaces is itself highly relevant. Indeed, the nature of *research by*

*design* leads to the production of knowledge that not only affects the product itself, but also, in the case of urban design, contributes to the knowledge of both the society that benefits from the design and the spatial environment where it is inserted [47].

Due to the implementation of urban design in public spaces, the importance not only of the social impact, but also the spatial impact has been recognized. Public space has an important role in cities' urbanity, and considering some anthropological perspectives, urbanity is defined as the capacity of triggered unstable and fluctuating social interactions [48]. Recalling the concept of public space, public spaces are places where thousands of activities and behaviors can occur, and precisely due to this capacity, social synergies and interactions are very difficult to predetermine and scale.

As Ballon suggests, living labs include an iterative and interactive cycle of activities, which mainly include elicitation, co-design, prototyping, testing, monitoring, and commercialization [5]. He indicates that some of the learning achievements derived from living labs emerge without a clear pre-definition, which is due to the complexity of real-life environments. This represents a major challenge in constructing a model to assess the deployment of urban elements in public spaces embedded in social contexts. The methods presented in this investigation provide a more understandable approach to the interrelation between society and the design of urban elements, which have a special impact in public spaces. Indeed, there is an overlap and range of interdependencies between the impact of urban design on citizens and vice versa. For this reason, analysis of the impact that an urban element has on its users might help to accelerate the inclusion of the role of society in urban design, as an adaptive process. The social issues concerning the physical environment imply relevant affectations in the course of design and planning [47].

To assess urban design, this study proposes a new model derived from the implementation of ULL, which includes a specific assessment phase during the implementation of temporary prototypes. This investigation indicates that using prototyping in public spaces could create the opportunity to assess the impact that these elements have on society and thus the opportunity to incorporate users' inputs in the urban design itself. The proposed model aims to track the whole process and presents a new approach that contemplates the overlaps among phases used in other living labs [6], a feature that reinforces the intervention of users in the design and development of urban elements. These overlaps are mainly thought to directly intervene in prototyping, as a testing process that is directly implemented in public spaces.

### 3.1. Urban Living Lab Four-Phase Model in Uncertain and Potentially Confusing Conditions

As stated in Section 2.2, previous studies have proposed models to assess ULLs that incorporate different stages, such as the ones proposed by Steen et al.: (1) research, (2) development, (3) testing, (4) implementation, and (5) commercialization. In their study, the authors conclude that not all ULLs follow the same process, but the majority follow some of these stages, with adaptations and modifications [7]. On the other hand, some projects only accomplished used of the mentioned characteristics. Thus, although being very close to ULLs, they cannot be recognized ULLs [6]. The model presented in the present study is proposed as a linear process for completing the design of MUEs in uncertain conditions that has a social value. It is composed of four different phases, which are established after the research and analysis of several studies: (1) problem and ideation, (2) development, (3) implementation/testing/assessment, and (4) final proposal.

In general, the proposed phases are consecutive, although some overlaps might be recorded. The model does not include the commercialization process, as it is focused on projects whose profits are generated in terms of social impact, value, and return. Hence, in the case study in which the model was applied, this last phase consisted of incorporating the results and the products in an open-source repository.

The model that describes the process of promoting the incorporation of ULLs in the design of cities, especially in terms of assessment. The ULL model that is presented in this paper is divided into four phases, which are mentioned below:



- PHASE 1 [Problem and Ideation]: Observation and determination of the problem that should be addressed, including citizen engagement, while giving free space for the ideas of users.
- PHASE 2 [Development]: A co-creative process adapted to the problem stated in the previous phase.
- PHASE 3 [Implementation, Testing, and Assessment]: The allocation of prototypes and evaluation of their impact.
- PHASE 4 [Final Proposal]: Final revision of the design, production of the final version, and elaboration of the documentation needed for its reproduction.

Figure 2 shows the Four-Phase Model constructed for evaluating urban designs through ULLs. The intervention, which involves the installation of the prototypes, is the input side of the model, while the impact is the output side [49]. The inputs and outputs are the clearest interrelations and overlaps between the phases.

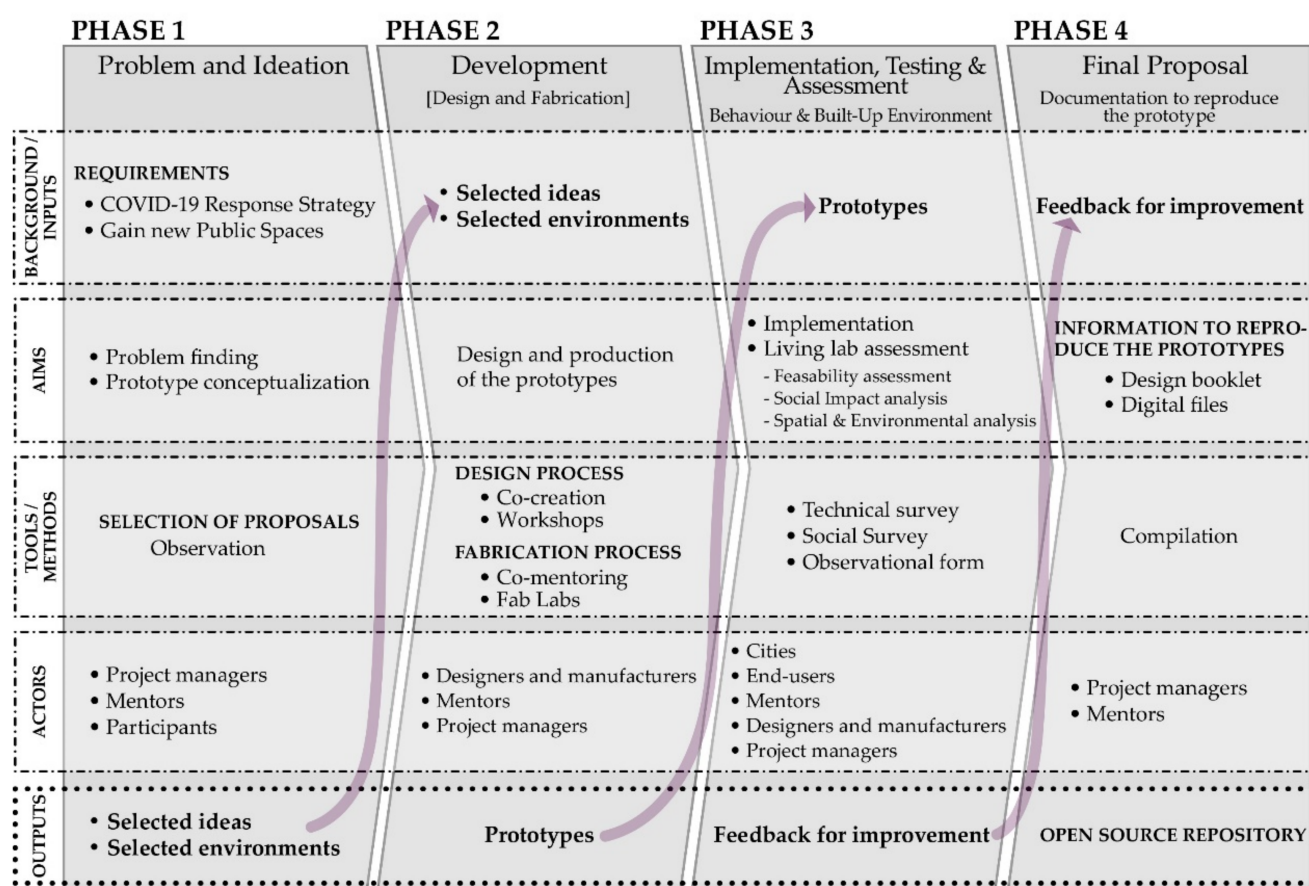


Figure 2. Four-phase model applied in urban design through urban living labs in uncertain and potentially confusing conditions.

The following segments of the document show how, once the model was applied in the case study project, the overlaps between the phases are multiplied, contributing to the determination of the model's validity.

### 3.2. Data Collection: Quantitative and Qualitative Data

The improvements in data collection techniques in recent years have been beneficial for designers and policymakers. However, to profit from these benefits, local environments need to be understood, a fact that can be achieved using qualitative and quantitative approaches [38].

Impact evaluation covers qualitative and quantitative methods, as well as ex-ante and ex-post methods. While quantitative results can be widespread, qualitative results may

not be. Comparing quantitative and qualitative approaches, the latter helps to measure potential impacts generated by a project, the mechanisms of such impacts, and the scope of the benefits perceived by users, as determined by personnel- and group-based interviews, generating valuable information for understanding the mechanisms through which users receive greater benefits.

The quantitative methods include ex-ante and ex-post approaches. The ex-ante design determines the possible benefits that an intervention has through simulation or modelling. Meanwhile, the ex-post approach bases its analysis on actual data gathered after the project implementation, measuring the actual impacts perceived by users [36,50].

### 3.3. Assessment Methodology

This subsection explains the methodology carried out to assess the impact of a project developed under the conditions provoked by the COVID-19 crisis. The work focuses on co-creation as a key factor. The data obtained from the impact analysis allowed for the identification of the vulnerabilities of the project, information that contributes to the elaboration of plans for the continuity and sustainability of the project.

The standardized impact measurement methodologies for ULL projects do not fit the analysis needed for projects developed under unconventional conditions, like those caused by the COVID-19 crisis. The impact measurement of COVID-19 projects impact assessment needs an ad hoc methodology. To design this methodology, Khandker et al., in the “Handbook on Impact Evaluation: Quantitative Methods and Practices”, provides a broad overview of the steps in designing and evaluating projects under uncertain and potentially confusing conditions [38].

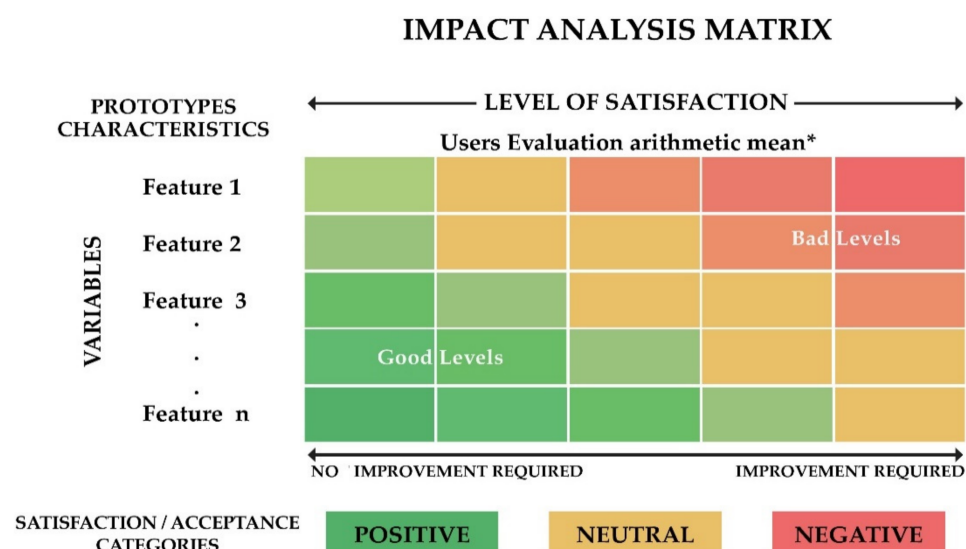
As stated in Section 2.3, the most important step in preparing an impact measurement is setting the initial objectives, arguing that the clearer and more specific these are, the better the results will be. Thus, an ULL assessment methodology should be developed to address the necessity of knowing if the initially established objectives have been met.

In the case of the evaluation of MUEs through ULLs, addressing aspects regarding the element itself, such as the materiality or fabrication processes, the effects caused by the ULL on the beneficiaries (users, citizens, etc.), and the effects on the occupied surroundings, is considered to be logical. Thus, three main aspects of the impact evaluation of ULLs are defined: (1) feasibility impact, (2) social impact, and (3) spatial impact.

#### 3.3.1. Feasibility Impact

As its concept dictates, a prototype is that “first copy that is made of a figure, an invention, or anything else, which serves as a model for making others like it.” Therefore, it is assumed that the main objective of its nature is to be replicable. A replication can only be made if and only if the prototype works correctly. To know if there are risks in its production, an evaluation of the features that make up the prototype (materials, manufacturing process, etc.) is needed. Then, the feasibility impact allows for the identification of possible risks of one kind or another. In the worst case, none of the features of an element are considered to be suitable, thus hindering its replicability.

The Probability/Impact (P/I) matrix is a tool used to determine the risks of a project that need detailed response plans. This matrix combines the probability and impact scores of the individual risks of the project and then ranks or prioritizes them for their easy handling. Based on the principles of the P/I matrix, a matrix for the feasibility impact assessment is proposed. As shown in Figure 3, the proposed tool identifies different trends or visible signs of change in a simple way, thanks to its visual faculties [51].



**Figure 3.** Impact analysis matrix.

### 3.3.2. Social Impact

According to Becker, social impact assessment is “the process of identifying the future consequences of a current or proposed action, which are related to individuals, organizations, and social micro-systems” [52]. Thus, the assessment of prototypes in real environments, such as ULLs, incorporates a forecast of people’s acceptance of a future action in urban design. In the Four-Phase Model, the impact of urban elements, before their final implementation, is tackled, which has made it possible to prove that society is one of the most relevant factors interacting with this final action. The impact that prototypes can have on society is crucial for further developing the elements in their definitive version.

In recent decades, there has been a clear trend towards including society in the design processes of co-creative living labs, for example, in [9,25,35]. However, the assessment question remains open. Indeed, its incorporation in the planning and decision-making processes might help in obtaining better future results. In terms of design, the social issues concerning the physical environment have significant content. Their overlapped interexchange could modify both society and the physical environment. As previously stated, socio-technical approaches examine how society conforms to technology, and space is not an exception. However, the complex production of space makes it more complicated to track the influence of users; for this reason, social impact assessment might be an option for evaluating the acceptance of new actions in public spaces.

### 3.3.3. Spatial Impact

In addition to the social impact, spatial impact is a key aspect for identifying the added value that any action gives to an urban environment. In the case of prototyped ULLs, which have their core in the implementation of urban elements in public spaces, the spatial impact could refer to the impact that an implemented element causes in public spaces, since, in this regard, it is a strange body. Therefore, the importance of space impact and its role in helping to inform an overall performance of what additional locations might look like for future prototypes are recognized.

The hundreds of activities and behaviors that take place in public spaces produce an infinity of synergies and interactions, and this diversity makes their predetermination and reproduction difficult to determine [48]. It is therefore necessary to establish evaluation criteria. According to the literature, all the factors that affect the built environment can be associated with the spatial impact, including among others alterations in the landscape, changes in the sound and atmospheric environment, modifications in urban planning, the forced expropriation of other elements or activities due to the implementation of an element, mobility alterations, changes in land use, and the presence of new activities [53].

Knowing the dynamics of an urban space can help in identifying the impact that an urban element has on its surrounding and vice versa. Therefore, both ex-ante and ex-post approaches contribute positively to the spatial analysis of ULL projects.

#### 4. ULL Case Study: The Four-Phase Model and the Three Impact Methods Applied to the Furnish Project

The Four-Phase Model proposed is designed to be applied to urban design processes through ULLs in uncertain conditions. To evaluate its usability, it was applied to a case study to further discuss its appropriateness and the assessment methods described in Section 3.2, which is used to prove its impact. Thus, in order to assess the urban design impact through ULLs, a project titled Furnish, developed in 2020, is examined.

Furnish is the acronym for *Fast Urban Responses for New Inclusive Spaces and Habitat*, a project that aimed to tackle the challenge of creating more public spaces through TU, reconfiguring streets and expanding the space for pedestrians and leisure using local digital manufacturing. The project was carried out by a consortium led by CARNET, with the participation of UPC · BarcelonaTech, Barcelona School of Design and Engineering (Elisava), the Institute for Advanced Architecture of Catalonia (IAAC), and the municipality of Milan and AMAT (<https://furnish.tech/>, accessed on 15 March 2021). Furnish aimed to address several urban mobility challenges caused by the health emergency crisis and it has been itemized to verify the validity and understand the value of impact assessments using prototypes and real-time experiments.

The objective of Furnish was to decrease the afflictions caused by the pandemic by creating new public spaces or improving the existing ones to avoid overcrowding and respect the social distancing needed to prevent the spread of COVID-19. It was conceived on the basis of the principles of TU, stated in Section 2.1, and a series of MUEs were designed, built, and installed in public spaces. The project was intended to have a beneficial impact not only in the environments where the MUEs were placed, but also in other contexts all over the world, where such initiatives are needed. For this reason, the project was based on an open-source license. This expected impact made it necessary to perform an accurate assessment, whose results would be part of the development of the MUEs.

It was a six-month-long project, developed during the COVID-19 pandemic and financed by the EIT Urban Mobility (<https://www.eiturbanmobility.eu/>, accessed on 15 March 2021).

##### 4.1. Description of the Project: European Call, Co-Creation Phase, Implementation, Testing, and Open-Source Repository

As mentioned above, Furnish aimed to think of new forms of urban elements to reconfigure public and interaction spaces, so that the effects caused by the COVID-19 can be decreased while promoting social cohesion. The general aims of Furnish were: (1) to catalyze mobility solutions for 21st-century cities, (2) to promote public space expansion, (3) to increase the distance for social cohesion, (4) to foster outdoor activities in place of indoor activities, (5) to follow DIY (Do It Yourself) logics, and (6) to produce resilience and sustainability.

The project followed the principles of the Urban Living Lab Four-Phase Model and has been developed in four different consecutive phases, which were each made up of five subsections: background/inputs, aims, tools/methods, actors, and outputs (see Figure 2). To develop the final proposals for MUEs, the four phases were followed, with no exception. The phases are described as follows:

- **PHASE 1 [Problem and Ideation]:** To go in-depth into the problem proposed by the project. In this first phase, an open innovation call was launched to select design and fabrication teams from all over Europe. In this phase, a first approach to the design, implementation allocation, team composition, and team selection took place. The approach to the design included the observation of the problem by citizens.

- PHASE 2 [Development]: Here, the mentoring and fabrication process took place. It lasted six weeks and consisted of a series of co-creation design and fabrication workshops, in which each team developed its prototype of an MUE.
- PHASE 3 [Implementation, Testing, and Assessment]: In this phase, the end-users were confronted with the prototypes, and the testing and assessment of the elements implanted in real environments took place.
- PHASE 4 [Final Proposal]: Final documentation and Open-Source Repository: the design booklets of the seven prototypes and the digital files of their production were gathered to make the Open-Source Repository available on the project's website.

#### 4.1.1. PHASE 1: Problem and Ideation

The Furnish project launched a call to select teams to participate in the design and fabrication of MUEs. The Furnish Open Innovation Call rules required that the participating teams were formed by two entities: (1) a design team (designers, architects, engineers, etc.), and (2) a fabrication team (makers, engineers, etc.) capable of designing, constructing, and implementing the required prototypes. A first interaction took place between the partners and all the participating teams to formulate the first approach to the design that would allow for selecting not only the teams, but also their problem ideation. Indeed, the proposals presented in response to the call were not actual designs, but rather approaches to a local problem ideation, derived from citizens' needs and queries. This step allowed for the production of an overview of the different problems related to open spaces during the pandemic across Europe, thus reinforcing the intention of being a co-creation project from the beginning. In this ideation phase, the teams that presented their proposal had engaged their own communities (from citizens to public administrations) to figure out the specific problematic to be approached first in their design.

The call received twenty-three proposals, and after a selection process, four teams from four different countries were selected. The three teams belonging to the project partners (UPC, ELISAVA, and IAAC) joined the four selected teams. These seven design teams built a prototype in five different European cities (see Figure 4).

PROTOTYPE NAME	TEAM NAME	CITY	COUNTRY	DESIGN AND FABRICATION ENTITIES	No. DESIGNERS	No. MAKERS
AEIUO	EAUM & I+D+ARQ	Guimarães	Portugal	School of Architecture of the University of Minho / I+D+Arq Universitat Politècnica de València / Design Institute of Guimarães (IDEGUI)	12	8
KONCH	NOT-19 (Aalto Fablab)	Espoo	Finland	Aalto Studios / Aalto Fablab	4	4
THEATRON	BP Gang	Budapest	Hungary	Fabrikacios Laboratorium Ltd. / FabLab Budapest	8	5
MUE:SLI	UNPark	Milan	Italy	Studio Ghigos / IDEAS srl	9	6
EDUS	UPC Team	Barcelona	Spain	Universitat Politècnica de Catalunya (UPC) (ETSABEPSEB) / Model Laboratory of the Barcelona School of Architecture (ETSAB)	10	4
VORA	Elisava Team	Barcelona	Spain	Elisava Barcelona School of Design and Engineering	13	14
Open Terrace	IAAC Team	Barcelona	Spain	IAAC Vallldaura Labs / Green Fab Lab	17	17

Figure 4. Description of the Furnish teams.

#### 4.1.2. PHASE 2: Development

As the project intended to create a common workspace based on collaboration, all seven teams participated in the design and fabrication process, which consisted of a series of virtual workshops, where all members of the seven teams interacted dynamically in the problem definition, ideation, and discussion of improvements of all the projects. In this second phase, a total of 73 designers and 58 makers participated (see Figure 4).

Within the first steps, each team presented its prototype, and each prototype was expected to be different. This mentoring co-creation process lasted six weeks and consisted



of 8 sessions. The first four were dedicated to the design process, while the second four were dedicated to the fabrication process. During the design process, all teams constantly shared their work and participated by giving feedback on the design and fabrication development of all the rest of the prototypes, so if any doubt arose during the mentoring process, it was resolved through the cooperation between the teams. As has been proven in other design experiments, ULL environments allow for collaboration in the innovation process [5], which is why it was decided to carry out the development phase through a co-creation lab.

Likewise, during the fabrication process, the makers met regularly online to collaborate to solve problems associated with the designs. The fabrication entity member of each team was in charge of the materialization of its respective prototype, resulting in the seven MUEs. The fabrication relied primarily on digital fabrication, technology whose unprecedented ability to deliver design intentions accurately and efficiently enabled all seven prototypes to be produced as planned in only three weeks. The deployed elements were designed and fabricated on a scale capable of being reproduced through local digital manufacturing, thus allowing for their quick deployment in open urban spaces.

The produced MUEs are described in Figure 5. As can be observed, all prototypes are diverse in terms of their shape and purpose.


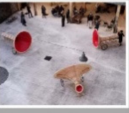












PROTOTYPE NAME	TEAM / CITY	CONCEPT				IMAGES	
		DESCRIPTION	AIMS	END-USERS	SPATIAL CONTEXT	ELEMENT	IN-SPACE
AEIUO	EAUM & I+D+ARQ (Guimarães)	<b>Movable autonomous spatial devices.</b> “Megaphone” thought to amplify the sound of drums.	<ul style="list-style-type: none"> <li>Generate new ways of expressing a traditional event.</li> <li>Interaction that keeps social distancing but reaches a great number of people.</li> </ul>	Multiple users	Diverse urban contexts		
KONCH	NOT-19 (Aalto Fablab) (Espoo)	<b>Multipurpose object.</b> Comfortable seat with an integrated audio system.	Enabling discussion or relaxation in the COVID19 situation.	Students school/university	<ul style="list-style-type: none"> <li>Any constellation up to 100 meters apart.</li> <li>Suitable for both outdoor, and indoor settings.</li> </ul>		
THEATRON	BP Gang (Budapest)	Installation of digitally fabricated sets of furniture and graphics.	<ul style="list-style-type: none"> <li>Transform the courtyards into new cores of community life.</li> <li>Foster the interaction between users through art, music, theatre, etc., while maintaining social distancing.</li> </ul>	Neighbors	Courtyards		
MUE:SLI	UNPark (Milan)	Urban furniture modular system.	<ul style="list-style-type: none"> <li>Create benches, tables, vertical supports and game surfaces for the public space.</li> <li>Adaptable to multiple function and uses related to sport, leisure and social inclusion.</li> </ul>	Multiple users	Any public space		
EDUS	UPC Team (Barcelona)	Ephemeral & itinerant architectural device.	To allow continuous learning and experimentation on the use and appropriation of urban spaces by citizens.	University students	Educational spaces		
VORA	Elisava Team (Barcelona)	Prototype as a system, not a specific object.	Build a safe boundary between cars and new pedestrianized spaces, so users can engage in leisure, educational and cultural activities.	Children Pedestrians	Areas near schools		
Open Terrace	IAAC Team (Barcelona)	Modular, adaptable system of reusable and rapidly deployable urban elements.	Reclaiming vehicular space for human use, extend sidewalks to become terraces.	Pedestrians	Vehicular spaces, streets		

Figure 5. Description of the seven prototypes.

#### 4.1.3. PHASE 3: Implementation, Testing, and Assessment

Once the co-creative process was finished, all seven prototypes were installed and tested in open spaces in five European cities—Guimarães, Espoo, Budapest, Milan, and Barcelona (see Figure 6)—from November to December 2020. This phase was the critical moment of the project, as it was the phase where the prototypes were tested.



**Figure 6.** Allocations of the seven prototypes.

The seven prototypes were different in terms of their designs, fabrication processes, ways of activating public spaces, and allocations. This diversity made the profiles of the ULL users different as well (see Figure 5).

More than three hundred people tested the seven prototypes. The assessment results gave direct feedback from the end-users, which was not only useful for re-defining the prototype, but for revising the goals of the Furnish project itself. Thus, to evaluate the prototypes' appropriateness, a series of tests were carried out.

As previously explained in Section 3.3, the assessment was divided into three impact analyses, which are introduced below and further explained in Section 4.3:

- Impact analysis I—Feasibility: confirming each prototype's fabrication assessment;
- Impact analysis II—Social impact: evaluating the social impact involving end-users (gets their direct feedback);
- Impact analysis III—Spatial impact: analyzing the prototypes' spatial impact in the allocation spaces (changes, mobility patterns, etc.).

#### 4.1.4. PHASE 4: Final Proposal

Considering the comments and survey results, the assessment of the seven prototypes resulted in improvements mainly in terms of accessibility, security, and services. The next step consisted in the compilation of the necessary documentation for the prototypes to be implemented all over the world. Thus, this step involved fulfilling one of the main objectives of the Furnish project, i.e., to allow for the reproduction and scaling-up of the prototypes, so that they can be implemented all over the world. The seven teams gathered all the necessary material, which was uploaded in a freely accessible open-source repository to be available within the project's website (<https://furnish.tech/results/>, accessed on 15 March 2021).

#### 4.2. The Furnish Project as an Urban Living Lab and Its Implicated Agents

As mentioned before in Section 2.1, according to Steen et al., the main characteristics of ULLs are their goals, activities, participants, and contexts [6]. The characteristics of Furnish were contrasted with these four requirements, which led to the conclusion that the project is a ULL. Its characteristics can be described as follows:

1. The goal: the project aimed to produce new prototypes to develop knowledge about urban elements deployed in open spaces to improve social cohesion while preserving physical distance (COVID-19 requirements). The prototypes are intended to be replicable worldwide.
2. The activities: the project followed the Four-Phase Model. The co-creation process took place in the second phase. Despite that other activities were repeated during the process, the design phase was limited to the second phase.
3. The participants: the actors within the project were diverse, depending on the developed prototype. First, the Furnish partners gathered public and private actors. Second, the design and fabrication entities, which made up the 'design community' of the project, were also composed of public and private professionals. Third, the users and citizens, whose roles differed depending on the prototype, were primarily committed to the third phase of the project.
4. The context: the seven prototypes were deployed in seven different open-air sites in five European cities. Their contact with citizens was direct and unlimited, allowing for real-life insights into their design.

Furnish is a ULL, although the iteration of its activities and the participation of users in the co-creative phase might be improved through further discussion. In terms of the actors' involvement, all designers and makers took part in the co-creation phase. Likewise, Furnish involved many entities and citizens. In Section 4.1, the actors' role in each phase is described. However, to give a clear picture of the key ones, the working, managing, and testing groups were as follows:

1. Project partners: All the professionals that worked in the overall organization of the four phases of the project.
2. Design teams and fabrication teams: All the professionals, researchers, design entities, and fabrication entities that worked in the development of the seven prototypes.
3. Users/citizens: All the citizens and users that partially participated in the co-creation phase and fully in the assessment phase.
4. Local administration: Local administrations or universities that contributed to the location of the prototypes in their public spaces.

Figure 7 shows the actors involved in the Furnish project. As can be seen, the citizens' characteristics (gender, age, and occupation) differ, depending on the prototype. This is due to the variety of activities carried out for each prototype.

LEVELS OF ACTORS									
1 <sup>o</sup> PROJECT COORDINATORS Academia, Public Administrators & City Planners									
PROTOTYPE NAME	2 <sup>o</sup> DESIGN COMMUNITY		3 <sup>o</sup> END USERS & CITIZENS					4 <sup>o</sup> LOCAL ADMINISTRATION	
	DESIGNERS	MAKERS	BEFORE		DURING THE IMPLEMENTATION				
AEIUO (Guimarães)	12	8	passing by: 193 staying: 0 gathering: 39 interacting: 0	passing by: 194 staying: 38 gathering: 23 interacting: 80	55 surveyed Women 56% Men 42% Non-binary 2% N.A. 0%	AGE <18 7% 19-35 65% 36-65 24% >65 4%	OCCUPATION Student 65% Employee 15% Entrepreneur 4% Public worker 15% Others 2% N.A. 2%	Câmara Municipal de Guimarães (Municipality)	
KONCH (Espoo)	4	4	passing by: 351 staying: 16 gathering: 19 interacting: 18	passing by: 275 staying: 55 gathering: 32 interacting: 28	20 surveyed Women 45% Men 45% Non-binary 10% N.A. 0%	AGE <18 0% 19-35 30% 36-65 70% >65 0%	OCCUPATION Student 10% Employee 60% Entrepreneur 5% Public worker 0% Others 10% N.A. 15%	Aalto University (University)	
THEATRON (Budapest)	8	5	passing by: 41 staying: 2 gathering: 0 interacting: 0	passing by: 41 staying: 27 gathering: 20 interacting: 21	65 surveyed Women 72% Men 28% Non-binary 0% N.A. 0%	AGE <18 no data 19-35 no data 36-65 no data >65 no data	OCCUPATION Student 85% Employee 9% Entrepreneur 5% Public worker 2% Others 0% N.A. 0%	None	
MUE.SLI (Milan)	9	6	passing by: 621 staying: 6 gathering: 0 interacting: 0	passing by: 422 staying: 164 gathering: 113 interacting: 56	59 surveyed Women 41% Men 56% Non-binary 3% N.A. 0%	AGE <18 7% 19-35 17% 36-65 63% >65 14%	OCCUPATION Student 7% Employee 53% Entrepreneur 17% Public worker 2% Others 17% N.A. 5%	Comune di Milano (Municipality)	
EDUS (Barcelona)	10	4	passing by: 496 staying: 26 gathering: 17 interacting: 17	passing by: 846 staying: 257 gathering: 200 interacting: 68	18 surveyed Women 67% Men 33% Non-binary 0% N.A. 0%	AGE <18 83% 19-35 17% 36-65 0% >65 0%	OCCUPATION Student 94% Employee 0% Entrepreneur 0% Public worker 6% Others 0% N.A. 0%	INS Barri Besòs (High School)	
VORA (Barcelona)	13	14	passing by: 1.054 staying: 243 gathering: 231 interacting: 227	passing by: 2.159 staying: 215 gathering: 152 interacting: 217	102 surveyed Women 68% Men 31% Non-binary 0% N.A. 1%	AGE <18 10% 19-35 16% 36-65 72% >65 3%	OCCUPATION Student 13% Employee 40% Entrepreneur 11% Public worker 26% Others 8% N.A. 2%	Ajuntament de Barcelona (Municipality)	
Open Terrace (Barcelona)	17	17	passing by: 208 staying: 32 gathering: 17 interacting: 17	passing by: 180 staying: 30 gathering: 18 interacting: 19	13 surveyed Women 38% Men 46% Non-binary 8% N.A. 8%	AGE <18 8% 19-35 58% 36-65 38% >65 0%	OCCUPATION Student 38% Employee 62% Entrepreneur 0% Public worker 6% Others 0% N.A. 0%	Ajuntament de Barcelona (Municipality)	

Figure 7. Levels of actors involved in the Furnish project.

#### 4.3. Impact Analysis of the Furnish Project

The assessment presented in Section 3 was applied to the Furnish project. The aforementioned specificity of the project implies matching the project's objectives with the assessment of the project. Thus, the assessment methodology for Furnish was developed to address the necessity of knowing if the prototypes are consistent with the initially established objectives:

- To promote social cohesion;
- To adapt temporary public spaces to meet the new challenges and opportunities that arise from the COVID-19 crisis; and
- To merge the challenge of gaining public space through tactical urbanism with local digital manufacturing.

With these objectives, it was decided to focus the evaluation on three aspects of the project's impact: The feasibility impact, social impact, and spatial impact. The Furnish project collected both qualitative and quantitative data and applied both ex-ante and ex-post approaches. The data collection was carried out through observational forms and surveys, and both methods have proven useful in impact analysis [37,38].

The seven prototypes were assessed under different conditions, but with a common purpose in a single project. Since the project's objectives were common, the assessment was



the same for all of the projects, as the challenge was not the deployment of the prototypes itself, but rather reproducing them all over the world.

The assessment phase had three main levels in terms of the actors' involvement:

1. The team level: evaluation of the prototype by the design team that developed it.
2. The project level: here, the 73 designers and makers were involved and, in some cases, a controlled user community.
3. The general level: all kinds of users and citizens were involved.

This paper does not include the evaluation of each prototype, but rather the strategy of assessment of the whole Furnish project, which is made up of the seven prototypes. The evaluation results are presented in phase three of the Four-Phase Model (see Figure 8).

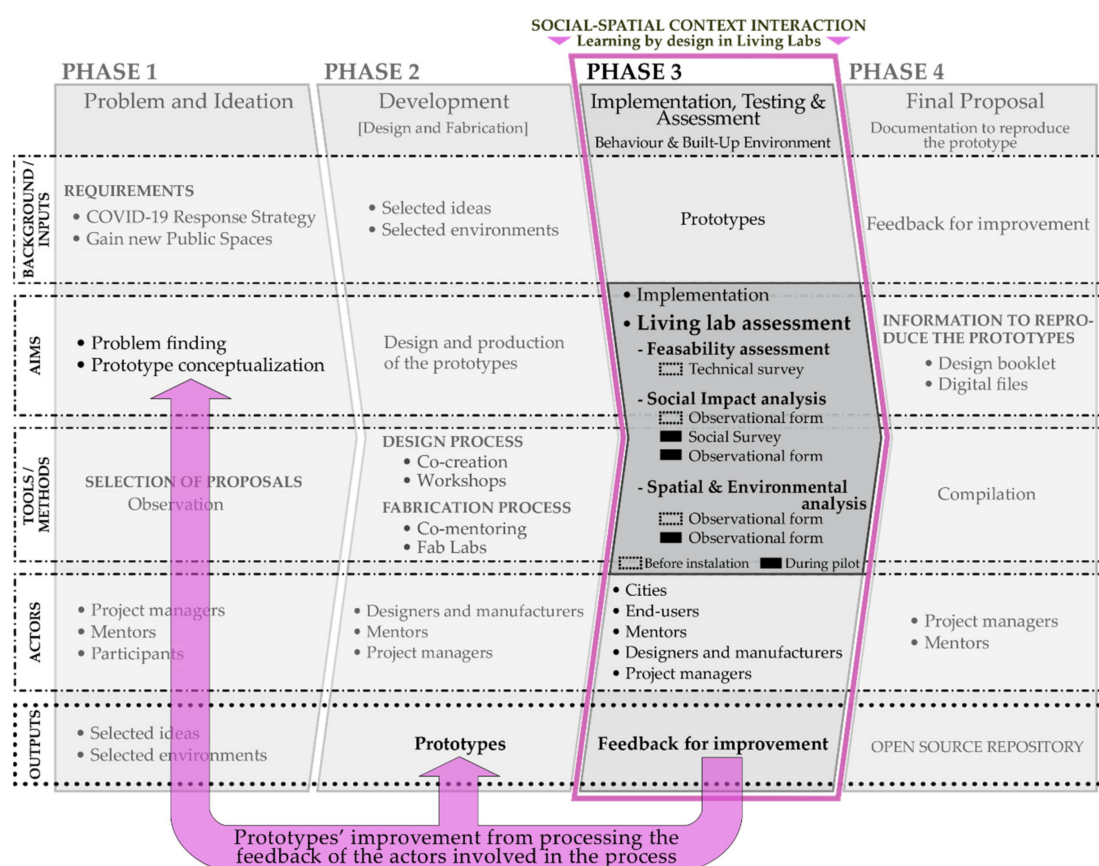


Figure 8. Four-phase model applied to the Furnish case study.

#### 4.3.1. Feasibility

Since one of the main objectives of Furnish was to make the prototypes reproducible and scalable worldwide, it should be easy to fabricate them in simple ateliers with digital fabrication tools. Hence, the MUE's reproduction evaluation was directly linked to its design. The first evaluation was related to the legibility of the fabrication process. To achieve this, an ex-ante approach was used to evaluate the viability of the prototypes. The actor level chosen for this evaluation was the project level. The ex-ante evaluation method consisted in confronting the designers and makers involved in the process with the seven prototypes.

Through an anonymous survey, each prototype was assessed by the rest of the teams. Thus, each partner answered six surveys, excluding the one corresponding to his/her own prototype. To ensure transparency and fair play, all respondents had access to all the information on each prototype (construction process and fabrication files). To collect the required information, a questionnaire was elaborated and included the following aspects:



(a) evaluation of the legibility, (b) easiness, (c) scalability, and (d) construction process. A total of 40 samples answered by 73 persons were collected (see Table 1).

**Table 1.** Feasibility survey numbers.

Feasibility Survey	
Actors Involved (Project Level)	Total Amount
Teams involved	7
Designers involved	73
Makers involved	58
Surveys answered	40

The questionnaire consisted of two parts. The first, composed of eleven questions, had the aim of determining the degree of concordance that the designers and makers had with the statements regarding the prototypes' feasibility. Using a five-point Likert scale, the participants were asked to rate some of the MUEs' features, from 1 ("not at all") to 5 ("yes, very much") and they were also able to respond with No Answer (NA). The second part consisted of one open question intended to collect qualitative information about the feasibility of fabrication.

The 11 questions corresponding to the first part were divided into five statements:

1. Feasibility: Evaluation of the legibility of the instructions to reproduce the prototype and the construction difficulty.
2. Sustainability: Evaluation of the adequate correspondence between the prototype and general sustainability.
3. Environmental adaptability: Evaluation of the capability of each prototype to adapt to its site in terms of the climate and geographic conditions.
4. Customization: Evaluation of the chance of adding new design features to the prototype.
5. Usability: Evaluation of the prototype's usage, transportation, and storage.

The results showed the features that needed to be revised in terms of the prototypes' design. The features with a better evaluation were the ones related to feasibility and legibility (see Table A1 in Appendix A). This was likely due to the importance that Furnish attributed to the temporary and rapid deployment of the MUEs to tackle the COVID-19 spread. Hence, it can be concluded that, in the first phase, all teams achieved this goal.

While both sustainability and environmental adaptability did not have negative outputs, it is also true that these features were not clearly tackled in that phase. The results also showed that further work on the usage of sustainable materials, focusing on the element's life cycle, should be included in the prototypes' fabrication. Additionally, the adaptability to weather (rain, wind, etc.) and geographical conditions should be revised, even if, considering the temporary nature of the elements, these recommendations could be included in the commercialization phase. Indeed, it must be noted, in connection with the mentioned results (see Table A1 in Appendix A), that the MUEs were prototypes that could be further developed using fabrication techniques that allow for the use of more resistant materials.

#### 4.3.2. Social Impact

The social impact analysis associated with the Furnish project aimed to estimate and make visible the social benefits produced by the installed prototypes. To design this assessment's methodology, two ideas were followed: the first was to measure the degree to which the main objectives of the project were achieved, and the second was to assess the design focus of the ULL approaches, which reiterates the benefits of user involvement in the design process [5]. Hence, users' opinions constitute one of the essential factors for measuring the social impact of the elements. Comprehending the nature of the relation between users and prototypes is key to understanding the perceived benefits, user appropriation, and the degree of users' satisfaction or, on the contrary, negative perception.

In Furnish, social impact was one of the major issues, especially concerning the citizens who used the space before and during the installation. This impact was assessed using two main tools: collecting both quantitative and qualitative data.

The quantitative information explained the prototype use frequency. These data were collected by counting the users. Defining the frequency and presence of users as an indicator may help in identifying if there is an appropriation of the implemented element or not. The qualitative information identified the benefits perceived by the MUEs' users. Both ex-ante and ex-post approaches were applied. In this sense, both types of information complement each other by promoting a comprehensive evaluation and an interesting contribution.

The tools used can be described as follows:

- Observation forms (OF): Based on the impact itself, the forms were filled before and during the prototypes' implementation.
- Surveys: The users filled out surveys during the prototypes' implementation, with aim of evaluating their satisfaction with the prototypes.

In this case, the actors involved were assigned to one of two levels. The OFs were filled at the team level; however, the observation of the team level took place in direct relation to the general level. The actors involved in the survey were the citizens. In both cases, the general level differs, depending on the prototype; likewise, the citizen types—the asked and the observed—vary for each of the seven MUEs. In the present analysis, these differences between the prototypes are disregarded, since the aim is to analyse the effectiveness of the project's assessment as a common general framework of development.

#### Observation Forms (OF)

This method aimed to record the changes in behavior through direct observation. To define the difference in behavior based on a cautious analysis, two different forms were elaborated: one to be filled before the installation and another to be filled during the installation.

- Observation form I—Before installation: This form was completed three times—morning, midday, and afternoon—during the course of one day. The groups responsible for the prototypes that had a great impact on weekends completed it six times—three times on a working day and three times on a non-working day. The form recorded the activities and mobility patterns before the prototype was installed and included: (a) General information (observer and prototype); (b) site identification (location and description); (c) date, time, and length of the observation period; (d) physical features (public space type and space elements); (e) users' frequency; (f) activity recording; (g) mobility features; and (h) modes of transport.
- Observation form II—During installation: This form was completed like the previous one, i.e., three times in the course of one day, and six times for the groups responsible for prototypes that had a huge impact on weekends. The goal of this second form was to record the changes in activities and mobility patterns caused by the prototype's installation. Based on the previous one, this form added a track of changes in activities and mobility patterns. COVID-19 health safety measures (distancing and mask use) were also recorded in both forms.

From the forms, both quantitative and qualitative data were obtained. A total of 27 OFs type I were filled, and this information helped the observers to understand the activities that took place on the site on a normal basis. The OF type II (30 forms completed) allowed the observers to determine if there were new activities, new mobility patterns, or any changes in either of the two aspects. Thanks to the use of these forms, the teams could register the impact that each prototype caused on the site.

In general, the prototypes' locations affected the number of activities and had less impact on the modes of transport. A total of 30 new activities were recorded, and 27 previous activities underwent some changes (in terms of frequency or duration). Table 2 shows the increase in users and activities. Likewise, the greatest increase was observed in interaction.

This result seems positive in terms of the project's impact evaluation, because it can be assumed that the aim of amplifying social cohesion was met.

**Table 2.** Observational form results. Users' behavior.

before			during		INCREASE <sup>1</sup>
Number of Forms	27		30		
Observed People:	Total	Average per Form	Total	Average per Form	
passing by	3157	116.93	3744	124.80	
staying	317	11.74	581	19.37	
gathering	326	12.07	574	19.13	
interacting	277	10.26	768	25.60	
Activities	52	1.93	79	2.63	
People in activities	2118	78.44	2545	84.83	
People moving	3003	111.22	4477	149.23	

<sup>1</sup> The background color indicates the relative increase comparing all features. The increase is ranged from yellow to dark green.

Regarding mobility patterns, the modes of transport used did not change from one period to the other. However, an increase in the number of commuters was observed, which may be due to the novelty caused by the prototypes. The predominant modes recorded were active ones (walking or cycling). This result is consistent with the soul of the project, which was to expand public spaces.

The two OFs (before/during) were great tools for registering the behavior patterns of users and, in some cases, even aided in the discovery of potential new uses for the prototypes, where some unexpected activities were recorded.

#### Surveys to users

The survey aimed to evaluate users' satisfaction with the prototype. It included several questions regarding the appropriateness, utility, and integration of the element. Likewise, the activities and changes generated due to the COVID-19 safety measures were evaluated. All the prototypes were assessed using the same survey, answered by a total of 332 citizens (see Table 3).

**Table 3.** Number of surveys of users.

SURVEY TO USERS	
Actors Involved (General Level)	Total Amount
Teams involved/prototypes assessed	7
Citizens involved	332
Surveys answered	332

The survey included four sections. The first two aimed to identify the type of user (gender, age, and occupation) and his/her relation to the site before the prototype's installation (site knowledge, frequency of use, and site satisfaction). The next two sections aimed to identify the impact caused by the prototype on users' daily activities, the appropriateness of the element for use, its level of comfort and legibility, and the adequacy of its response to COVID-19 (see Table A2 in Appendix A).

The data showed that the prototypes' appropriateness and legibility received the highest positive evaluations. In general, more than 80% of the sample liked the prototypes (see Table A2 in Appendix A). On the other hand, the reinforcement of previous activities received fewer positive answers. This may be explained by the lack of previous interaction activities present in the prototypes' locations.

#### 4.3.3. Spatial Impact

The prototypes were conceived as MUEs, so the relationship with their immediate surroundings was an aspect of the utmost importance. In particular, it was necessary to assess the elements and state the criterion needed to further implement them in other sites. Table 4 collects information about the open spaces and their major relations. As stated before, the project deployed the prototypes in diverse sites, which enables their reproduction in other locations. Table 4 shows the typologies of the open spaces where the prototypes were installed.

**Table 4.** Characteristics of the locations of the prototypes.

	Type of Open Space:	Linked to:
Prototype 1	Passage Municipal Square Urban interior	Civic facility University Commerce
Prototype 2	Urban interior	University
Prototype 3	Courtyard	Residence
Prototype 4	Street Passage Municipal Park	Residence Commerce
Prototype 5	Street	School Residence Commerce
Prototype 6	Street	School
Prototype 7	Café Terrace	Commerce

To record this impact, an OF to evaluate the changes in the space was used. The observer had to perceive the impact caused by the element on the space and vice versa. Likewise, this form was useful, since it aided in the tracking of the spatial interactions and conflicts that may occur during the implementation.

#### Spatial form

This form was completed to analyze the spatial impact caused by each prototype, once they were installed. The form included (a) a description of the spatial changes caused to the surroundings, (b) a description of the physical changes caused to the prototype by users or designers, (c) an overall view of the installed prototype, (d) a description of the spatial impact concerning the required physical distancing (COVID-19 measures), and (e) a brief description of the ecological cycle of the surrounding area. The form incorporated visual material (images of the installation and drawings of spatial affections).

The results of the spatial forms allowed for the registration of some characteristics. Firstly, the spatial changes were mainly related to its use, its occupation, and, especially, its perception. The latter could be related to the findings in the previous forms, which showed that there was an increase in interaction in the space. Some prototypes also changed the space in terms of materiality; for example, three of them implied changes in the material features of the open space: one colored the asphalt, another remade the concrete pavement, and another covered the asphalt with a wooden platform.

As previously explained, urban elements were also affected by the space, and according to the form, they were mainly affected in terms of the composition, texture, materiality, and, in some cases, in their structures (e.g., an amplified size). Likewise, some prototypes had to be adapted to their location, considering the features of some sites, such as the irregularities of sidewalks. Others had a negative interaction with users and suffered from vandalism.

The spatial form incorporated a section to describe the strategies incorporated in the urban elements in response to COVID-19. Some elements were intended to be used

separately, so users could interact with the prototypes while avoiding direct contact. This created the necessity for a greater space allocation. Others incorporated plugins to develop different activities, giving the prototype a wide range of variations. Another strategy was based on amplifying or connecting sound from one place to another, thus avoiding the necessity for crowding in order to communicate. The other strategies reconfigured the existing open spaces, promoting open-air interaction.

Spatial impact analysis brought qualitative data as well, such as many graphic documents (location and site plans, axonometric views, etc.), which gave exact features of the spatial conditions affecting the prototypes. In this case, drawings are key analytical tools for comprehending the criteria applied to implement the prototypes in new sites, which the project demanded.

#### 4.4. Evaluation of the Results of the Furnish Project Assessment

The assessment of the prototypes provided key information about potential improvements. The assessment was built in consideration of the importance of three issues—feasibility, social impact, and spatial impact—in the core of the Furnish project, building a direct link between the goals of the project and the performed impact assessments, whose results are briefly summarized below:

- Impact analysis I—Feasibility impact: The assessment resulted in a significant achievement in this aspect.
- Impact analysis II—Social impact: An increase in activities was recorded. Interaction was facilitated by the project, and people generally liked the MUEs, which were generally appropriate for society.
- Impact analysis III—Spatial impact: This assessment had special relevance due to the spatial characteristic of the urban elements. It helped to provide an overall performance evaluation, which allowed for an evaluation of how future prototypes might be received in other locations.

Moreover, to evaluate the overall appropriateness of the impact of the prototypes, the five principles stated by Ståhlbröst were followed (see Section 2.3) [40]. She proclaims that a living lab impact analysis should be guided by value, sustainability, influence, realism, and openness. In Table 5, the principles are linked to the tools involved in the assessment of the prototypes. As can be seen, different tools served to evaluate the items proposed by Ståhlbröst, differing only in terms of the commercial perspective, since the Furnish project was not conceived to generate economic benefits.

**Table 5.** Furnish principles linked with assessment tools.

Principles	Description of the Principle	Furnish Assessment Tools
Value	Analyzing added value for users	Survey of users
Sustainability	Analyzing responsibility in environmental, social, and economic terms	Feasibility survey
		Spatial form
Influence	Analyzing the influence of users in the design of the innovation process (urban design)	Observation form I and II: Before and during installation
		Survey of users
Realism	Analyzing real-use situations and behavior analysis	Observation form I and II: Before and during installation
Openness	Establishing an adequate level of openness in the development of ideas, activities and results	Survey of users

The development of the Furnish project allowed to conclude that ULL environments foster collaboration within the innovation process, which can also be confirmed in living lab environments [5]. Besides, the greater the interactions in ULLs, the more robustness there is between new urban designs and their social environments. The interactions could multiply,



and their assessment could be used to drive further and improved development of future prototypes. This allows reiterating the extreme value that the assessment phase has for the prototypes' design process, especially due to providing socio-technical improvements.

Finally, concerning the relevance of the impact assessment, as Boelen stated, in spatial planning and urban design, there is no single optimal solution. Therefore, all prototypes could reach their best functionality thanks to an iterative design process [49]. In short, in urban design there is no final response to be found; rather, each prototype should be seen as a part of a whole process of improving a common problem-solving ideation.

## 5. Discussion

According to the Socio-technical System Theory, design processes do not directly respond to optimization results, but they entail a process of embodiment in society [45,47,49].

Using prototyping as a sort of essay in public space derived from tactical urbanism initiatives, urban designs can be improved more quickly, since they are an accepted part of the iterative process needed to link an urban element with its social environment. Urban element prototyping and testing in ULLs has been proven to be a robust tool in the assessment of urban elements, especially thanks to feasibility, social, and spatial impact analysis. The assessment of urban elements through ULLs is feasible and allows designers to improve their initial results.

Furthermore, having recently been incorporated into the development of urban planning dynamics, ULLs are key actors not only in the testing of prototypes for urban design, but also in its co-creation process [9,26]. ULLs are seen as powerful iterative design tools that include creative and evaluative phases, which has been proven thanks to the methods presented in this article and the assessment carried out in connection with the Furnish project.

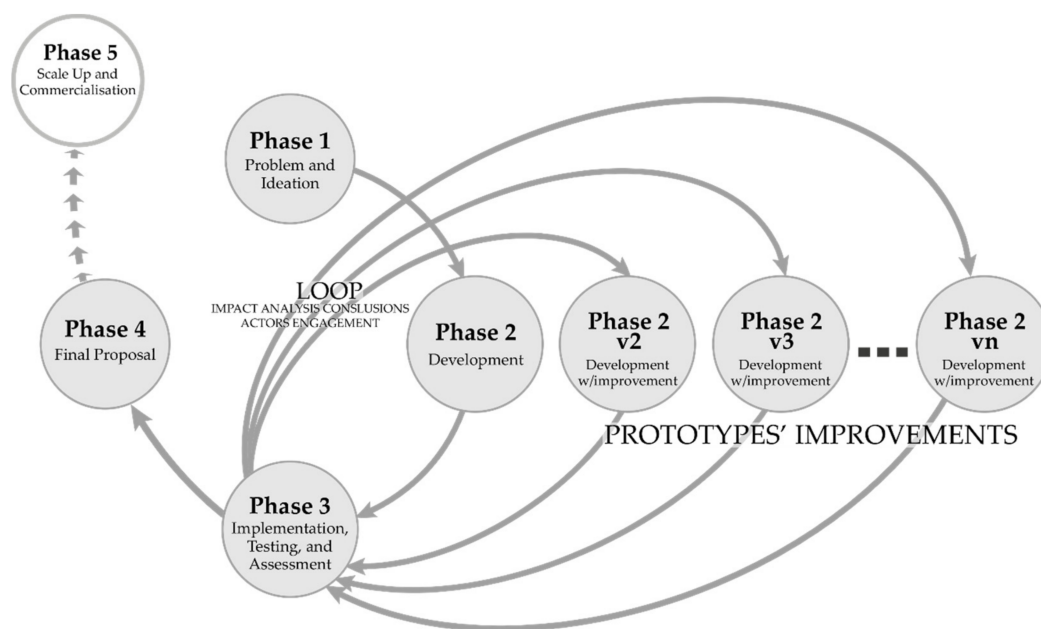
The Furnish project has been a useful case study, as we were able to apply the Four-Phase Model and the proposed assessment methods to it. The major strengths of the model appeared to be as follows. (1) It was adequate for developing an urban design project through ULLs in uncertain conditions; (2) the overlaps in the phases reinforced its organizational approach and its consecutive relations; (3) the categories of each phase helped to construct the whole applied framework of the Furnish project; (4) it was a leading tool for assessing the prototyping process of design; and (5) the specific assessment methods were properly stated, thanks to the model. The major weaknesses of the model were: (1) its unspecified application to more permanent installations; (2) the informal use of assessment as a design tool in an identified iterative process; and (3) the lack of repetitive engagement of citizens and users in the design.

Following this rating and even if the results of such a methodology are promising, some questions remain. The first issue concerns the improvement of the iteration between the design and assessment phases, an action that might improve the evolution of urban design. The second issue that may be tackled is how to enhance and increase users' engagement in all phases of the design process. Finally, the Four-Phase Model has been useful in uncertain and potentially confusing conditions, such as those associated with the Furnish project, but the model might also be applied to longer and more permanent situations.

This discussion aims to improve the whole ULLs process, focusing on the iterative principle in which ULL activities should be developed, this particularity being a weakness in the case of the Four-Phase Model. This iterative principle led to a modification of the initial model, proposing a new one that explores the iterative perspective of ULLs in both the design and assessment phases of prototyping. Therefore, this study proposes the LOOP scheme (see Figure 9).

The LOOP scheme is a spiral of continuous improvements, including the continuous evaluation of urban design prototypes. In micro-level interventions, such as the ones performed in the Furnish project, there are actors, e.g., end-users, who are not involved in the co-creation process. However, the proposed LOOP might improve the overlapping between the design, implementation, and assessment phases, so that all actors can be

involved. The LOOP Scheme is derived from the Four-Phase Model and includes design iteration, a continuous and evolving process that allows for the incorporation of further improvements, thanks to the repetition of the testing process and development (see Figure 9). Therefore, this study proposes to apply the LOOP Scheme in ULL projects to replace the Four-Phase Model.



**Figure 9.** LOOP scheme. An interactive process for urban design in Living Labs.

Many authors conclude that the planning process has to be transformed into a process with multiple sources of feedback and become more reflexive [54]. The LOOP scheme provides this transformation by including all kinds of actors and improving their involvement in design. The iterative process of the development phase and its continuous assessment includes the idea that the experiment is not closed, which may contribute to the identification, in the first instance, of the strengths and weaknesses of the prototype. The new assessment stage may bring new insights into the process, and the loop could be repeated as many times as desired or required, thus allowing for continuous improvement of the prototypes and an increasing engagement of citizens. This iterative process could bring benefits by helping to identify the long-term impacts of prototypes and rectify the undesirable ones. The assessment phase might also evolve and include in the new prototypes, solutions to the needs derived from previous assessments, variations in design, or changes in the main goals of projects. This is particularly importance, since urban designs are supposed to be placed within cities, which are constantly evolving, therefore the new proposed scheme need to keep pace.

Cities are complex systems in constant evolution, so that, urban design and planning evolvability ought to be improved. Its social and spatial impacts should affect how it adapts to the changing processes of cities in a back and forth process, which can be modelled as a loop.

## 6. Conclusions

Concerning the complex environmental challenges faced by cities, whose nature is highly complex, if factors such as pandemics, natural disasters, or other events that further intensify the complexity of urban contexts occur, prototyping seems to be a suitable approach for confronting them. These problems, which arise rapidly and are not necessarily predictable, are, therefore, not included in planning. This new approach of quickly developing design solutions in uncertain times could be, as demonstrated, a method for facing these conditions and can be assessed by a model that includes ULLs.

This research on the assessment of urban design through ULLs offers deep insights into how successful prototyping projects can be developed. Thanks to the empirical assessment of the Furnish project, this research concludes that the LOOP Scheme (see Figure 9) has the potential to reinforce the successful deployment of such projects.

To apply this scheme, it is relevant to consider the following:

- Users' iterative role [social impact]: Users' opinions should be part of all of the phases of projects and especially in the iteration process between Phase 2 (Development) and Phase 3 (Implementation, Assessment, and Testing). The inclusion of users' perceptions in the design assessment produces elements that can more easily be incorporated into society, according to socio-technical principles. Users should also be integrated in the Ideation Phase (Phase 1), in which new tools, such as gamification, should help to identify the initial problematic, especially in finding the right problem for engaging end-users [55].
- Defining the assessment according to the objectives: The assessment of urban design projects should be designed considering the main goals of the project.
- Spatial relevance [spatial impact]: Urban design projects affect the public spaces in cities. They should be included in all phases.
- Temporary approaches [uncertain conditions]: The project needs to define its temporary framework. Prototyping, as its definition dictates, does not provide the definitive version of an element, but rather aims to make it scalable. Therefore, regarding future applications, the materialisation, development, and assessment of prototypes might be altered according to the conditions of future contexts. For instance, if it is a project that is to be executed under uncertain conditions, aspects such as a rapid response to an emergency, as in the case of Furnish, should affect all phases.
- Scaling [feasibility impact]: If prototypes should be developed in other situations or locations, there is a need to assess the feasibility of their reproduction.
- Fighting for the Right to the City [social impact assessment]: ULL projects have a highly valuable social impact. Therefore, they should incorporate inclusiveness, and social assessment is a key means for proving its value.

The future of urban design depends on the increasing participation of society, especially in experimental terms, moving from a laboratory approach to real life. In this sense, the iterative nature of ULLs might match the process of urban design and its socio-technical challenges. The evolving nature of urban environments should affect present design processes, adding to city planning and providing new interacting layers that incorporate the social system in a process that recovers socio-technical principles. Hence, design in cities should incorporate co-creation, social impact analysis, and the setting up of ULLs [9,26,45,47,49].

The findings of this research consist in applying the new LOOP Scheme to new prototyping projects associated with generating urban design elements. The LOOP scheme was a direct result of the evaluation carried out within the Furnish project. Since Furnish was a six-month-long project, the application of this scheme was not possible. However, these results show that future research might include the evaluation of ULL projects and improve the iterative process in urban design by incorporating the evolving perspective of design. As a result, the new proposed scheme might allow for a deeper evaluation of future urban design projects, thus enabling a comparison of their results. The iterative nature of the LOOP Scheme allows ULL projects to be easily improved by enhancing them or even incorporating citizen engagement in the design. Finally, the temporary approach of ULLs might be changed to a more permanent one, thus bringing new opportunities for research on the enduring process of urban design.

**Author Contributions:** Conceptualization, I.A., A.C., L.P. and J.M. (Section 2.1); methodology, I.A. and A.C.; formal analysis, I.A. and A.C.; investigation, I.A. and A.C.; resources, I.A., A.C. and J.M. (Section 2.1); data curation, I.A. and A.C.; writing—original draft preparation, I.A., A.C. and J.M. (Section 2.1); writing—review and editing, A.C., L.P., I.A. and M.E.; visualization, A.C. and I.A.; supervision, L.P. and M.E.; project administration, I.A., A.C. and L.P.; funding acquisition, L.P. and A.C. All authors have read and agreed to the published version of the manuscript.

**Funding:** The Furnish project was partially funded under the COVID 2021 call (KAVA 20237) by EIT Urban Mobility, an initiative of the European Institute of Innovation and Technology (EIT). Learn more at [eiturbanmobility.eu](http://eiturbanmobility.eu).

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data presented in this study can be made available on request by the corresponding author. The data are not publicly available due to the internal assessment process of each design team.

**Acknowledgments:** We would like to acknowledge the contribution of all design teams and partners in the Furnish project: CARNET, UPC · BarcelonaTech, Elisava, IAAC, Comune di Milano, AMAT, Ajuntament de Barcelona, EAUM & I+D+Arq, NOT-19 (Aalto Fablab), BP Gang, and UNPark.

**Conflicts of Interest:** The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

## Appendix A

**Table A1.** Feasibility survey results.

Assessed Feature	Designers Evaluation Arithmetic Mean <sup>1,2</sup>			
	Pos.	Neu.	Neg.	NA
<b>Feasibility</b>				
There is a clear correspondence between the digital fabrication files and the pieces that need to be produced.	67%	24%	3%	5%
It is easy to assemble the pieces fabricated to build the prototype.	56%	27%	14%	3%
It is easy and feasible to find the materials with which the prototype was made.	83%	15%	2%	0%
The instructions for fabricating and building the prototype are legible and easy to follow.	62%	26%	5%	7%
<b>Sustainability</b>				
The selection of materials and techniques used to fabricate and assemble the prototype consider environmental aspects.	29%	46%	25%	0%
<b>Environmental adaptability</b>				
The prototype resists adverse climate conditions (rain, snow, wind, etc.).	52%	12%	36%	0%
The prototype (its materials and design) can be adapted to new physical and geographical conditions (e.g., slopes, new pavements, etc.).	37%	36%	27%	0%
<b>Customization</b>				
It is possible to customize the prototype.	40%	29%	31%	0%
The prototype includes alternatives in terms of assemblage to scale or redistribute it.	47%	36%	14%	3%
<b>Usability</b>				
It is feasible to move the prototype through either transport or disassembling and reassembling it again.	65%	25%	10%	0%
It is easy to store the prototype.	68%	23%	9%	0%

<sup>1</sup> The arithmetic mean represents the average positive, neutral, negative, and NA answers in the evaluation of the seven prototypes. These are aggregated numbers. Each prototype has also been analyzed individually in the project's internal assessment process. <sup>2</sup> The background color indicates the relative positive evaluation comparing all features. The evaluation is ranged from red to dark green.

Table A2. Results of the surveys of the users.

Assessed Feature	Users Evaluation Arithmetic Mean <sup>1,2</sup>			
	Pos.	Neu.	Neg.	NA
<b>Appropriateness</b>				
The urban element grabs the attention of the user.	85%	12%	3%	0%
The urban element is appropriate for a public/common space.	80%	6%	10%	3%
The urban element is appropriate for use.	74%	9%	14%	4%
The prototype can stay longer at the site.	77%	14%	8%	1%
The urban element is appropriate for being repeated and placed at other sites in the city.	75%	10%	12%	3%
<b>Comfort and legibility</b>				
The urban element is easy to use.	79%	6%	8%	7%
The urban element is comfortable.	52%	22%	15%	11%
The user likes the urban element.	81%	10%	7%	1%
<b>Integration of the element and activities</b>				
The urban element is well integrated in this public/common space.	75%	10%	14%	0%
The prototype does not interfere in any of the previous activities that take place at this site.	66%	0%	15%	19%
The prototype reinforces any of the previous activities that took place at this site.	40%	0%	32%	28%
<b>Covid-19 response</b>				
The prototype promotes physical distancing between users.	53%	15%	27%	5%
The prototype prevents the spread of COVID-19.	47%	23%	20%	9%

<sup>1</sup> The arithmetic mean represents the average positive, neutral, negative, and N/A answers in the evaluation of the seven prototypes. These are aggregated numbers. Each prototype has also been analyzed individually in the project's internal assessment process. <sup>2</sup> The background color indicates the relative positive evaluation comparing all features. The evaluation is ranged from red to dark green.

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