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The Role of Mock-ups in the Anticipation of the User Experience within a Living Lab: an Empirical Study

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Abstract—This paper presents an empirical study focusing on the role of mock-ups to support user/citizens co-creation and the anticipation of the User eXperience within a specific urban Living Lab. Scholars have previously identified different principles characterizing a Living Lab, such as: “realism”, spontaneity, continuity and empowerment, which represent the “live” dimension of Living Labs. However, these principles are quite difficult to practically implement. Nonetheless, we conducted an experiment in the context of an urban project dedicated to the design of mobility stations that reveals the paramount importance of the mock-up role for implementing the “realism” principle. The findings unveil the great potential of close-to-real-life immersion of users/citizens in realistic environments to not only fulfilling the “realism” principle but also greatly contributing to the adoption by users/citizens. Finally, this study gives some elements to support citizens’ engagement in the co-creation stage of the urban design process towards the realization of smart-cities.

Keywords—Living Lab; user-centered design; immersion; adoption; mock-up; user experience; smart city; urban project

I. INTRODUCTION

In 2010, we got the opportunity to support the design of a participatory process to rebuild an eco-neighborhood in the city center of Nancy (North-East part of France). The origin of the project was the wishes of both the Local authorities and urban decision makers to take into account the “usage point of view” from the earlier stage of the project. The map (see Fig. 1) highlights the urban project named “Nancy Grand Coeur”. It is an area of 150 000 m² upgraded by town planners and within the public debate. The operational challenge for our team was to coordinate at the same time the participatory process, which is a democratic issue, and the urban design process, which is an engineering issue, and this in a sustainability perspective. Indeed, the public authorities wish to have a method to propose more sustainable solution. For example, having a new district allowing economical activities while supporting the environment and the quality of life. The project covered different ecological aspects, such as: health, mobility, energy efficiency, green building, etc. Furthermore, according to the local town-planning specialists, this project is going to last between 10 and 15 years. Thus, that district gives the opportunity to conduct experiments with all stakeholders and especially citizens in order to transform Nancy as a smarter city. To engage citizens in the urban design process, the

research team decided to investigate the possibility to use the Living Lab (LL) concept in the context of an urban project.

Since 2011, our research team and the town-planning team of the Greater Nancy designed a process with three stages [1]. 1st stage in 2011: diagnosis of the potential future usages induced by an eco-neighborhood. 2nd stage in 2012: need analysis sessions in order to find out potential users’ experiences. 3rd stage in 2013-2014: evaluation of potential solutions with citizens and technicians. Almost 300 unique persons (citizens, territorial engineers, experts, elected representatives, students) were involved during 31 workshops for 3 years.

The first observations of the three stages [1] show that adopting the LL concept for an urban project is pertinent. However, the mutation of a city and the renovation of a neighborhood require a long period of time to be achieved. A certain period of time is necessary to prepare and conduct experiments. Researchers have to be engaged in the project over a long period of time in order to be able to understand the different phenomena and to observe the process on a longer run.

A previous paper [1] provided the key factors of success for this specific application field of managing urban project that imply to take simultaneously into account strategic, tactic, and operational dimensions. This sustainable approach needs new tools, technologies and processes in order to take into account or engage the various stakeholders in this transformation; be patient and aware that the system can show resistance and needs time to evolve. Furthermore, they highlight that regular contacts between the researchers and the actors of the urban project allow to share knowledge and to develop the new practices, in particular between territorial engineers and users [2]. But, according to a LL perspective, several questions remain. How this case study can provide evidences on the scientific debate of the LL issues? In particular, how to generate real-life situation with potential users while the project will stay in progress for a long period of time; even users might change during the long term design process; technologies or material might evolve as well during both the design and development processes?

The design of the first mobility station during the rehabilitation of the Charles III Square (see Fig. 1) gives us the opportunity to tackle these questions. Indeed, that square is very close to the eco-neighborhood and plays a major role in

the mobility of the city (e.g. bus lane, bus station, car-sharing, parking lot, pedestrian precinct, etc.). In this paper we propose to share our experience of implementing a LL approach for the design of urban project. We focus especially on the different tactics used to connect participants to real-life situations in order to anticipate their User eXperience (UX). However, we do not discuss on the study of interactions within a digital mock-up that will be reported later on in another paper.

After a literature review underlining the significance of real-life within LL and the link with the concept of adoption in section 2; section 3 presents the developed protocol through an empirical approach. Section 4 describes the findings we obtained during the design of a mobility station in the eco-neighborhood in progress. Finally, in section 5 our proposal is discussed as well as implications for further LLs' experiments are introduced.



Fig. 1. Urban context of the empirical study within a Living Lab, adapted from [1].

II. LIVING LAB LITERATURE REVIEW

A. Living lab and urban project: the issue of real-life

LL concept is recent and quite controversial. Mitchell is known for being at the origin of the LL concept in the early 2000's. The quick development of ICT allows as well collecting a huge amount of real life data (Wi-Fi activity, cars traffic, money circulation, etc.) in short period of times on which it is possible to build the future development decisions. Mitchell considers cities and buildings as live laboratories in which designers can experiment solutions for designing new products.

A LL is intended to be an open user-centered innovation ecosystem based on a Public-Private-People Partnership (PPPP) in order to get more benefits, such as: the private sphere is flexible and reactive in the project process; the public sphere stands for the legal and financial frameworks; the confrontation with the citizens sphere helps to adjust the product under development to real users' needs [3]. The LL concept mobilizes then numerous stakeholders, such as: industries, large companies, SMEs, entrepreneurs, associations, users' communities, and universities. The application domains of LL projects cover a wide spectrum of societal challenges, such as: health, energy & environment, well-being, social inclusion, mobility, education, media, industry, tourism, and art.

The values and the mindset associated with the LL concept, such as the five principles for LL, namely: continuity, users' empowerment, real-life, spontaneity, openness, identified by Staahlbröst [4] remain key challenges in particular for long term project as urban project. Indeed, LL concept is sometime used to investigate or design projects for cities or regions. For example, [5], [6], [7] intend to understand and identify boundary conditions for successful Urban LLs to support Smart City. We also adopted this point of view for designing urban project in the LL approach [1], [8], [9]. Furthermore, real-life validation is the essence of a LL approach allowing considering the external constraints of the usage situation.

B. Enrich User eXperience and Experience Design

Previous studies [10], [4], [11], [12] designed the conceptual framework of the LL approach, which put users into the center of value creation for projects, enterprises, or for the Society. In fact, users become unavoidable stakeholders of the design process and different user-centered design approaches appeared since the past decades: we can name as examples Contextual Design [13], Emotional Design [14], User Experience and Experience Design [15]–[18], Interaction Design [19]–[21]. All these approaches share the common aim of integrating people's usages in the design process, knowing that usage is made of practices, as well as of opinions, representations and meanings the user is building by using a product [22]. Since the early 2000's, a new way to integrate usages in the design process is proposed with the LLs: this approach aims to follow a systemic analysis [23] in order to highlight emerging behaviors and user patterns and to assess the socio-economic implications of the new product [3]. The objective is not to define if the product under development fulfills users' expectations but to evaluate if this future product

can easily integrate the actual usages [24]. So we have to assess the potential adoption and appropriation of the product under development. Furthermore, the LL concept is situated at the crossroad of different society trends, like citizens' empowerment, and paradigms such as Internet of Things or Open User-Centered innovation [25],[26]. Fig. 2 proposes a chronology of the main design approaches that illustrates the path from technology-centered to human-centered design approaches. It initiates a transition toward a design that considers the product, the user and its ecosystem in the same space and time, as earlier as possible.

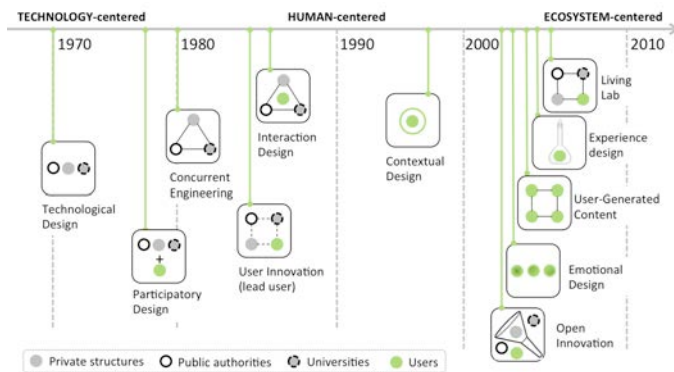


Fig. 2. Chronological map of the appearance in the literature between 1970 and 2010 of design methods and the consideration of users, adapted from [27]

C. Product service adoption

This chronology shows the evolution in the appearance of the consideration of users between 1970 and 2010. The generation of the value creation moves from vision usage to the engagement of the users and the understanding of its ecosystem.

From the 1980's, user evolves from observation subject toward design actor [28]. The added-value of the user's new angle of view and his everyday life expertise are revealed in numerous studies, starting with Von Hippel [29], [30]. The user is more and more considered as a critical ingredient of the innovation process (like for example in participatory design or user innovation). At the end of the 1990's, the user's perception is more considered. Traditional design methods and tools were dealt with traditional properties by asking them explicitly their opinions and/or expectations but humans follow an emotional reasoning too [14]. This emotional part is mostly unconscious and cannot be addressed with an explicit approach, as it is located at a deep level of user's knowledge [31]. Design methods, such as emotional design and experience design are more focused on the perceptual level. Furthermore, focusing on the technological dimension and its related performance does not lead to product adoption by users. Scholars have previously demonstrated the importance of other elements such as: individual predispositions; compatibility with actual usages; pressure on social learning or impact on social status [32]–[36]. Studies on the acceptance of the technology are not new as shown by Technology Acceptance Model (TAM) with the "perceived ease of use" and the "perceived usefulness" of a new technology [37]. The theory of Diffusion

of innovations links the characteristic of innovation and the favorable or unfavorable attitude toward adopting that innovation [38]. The Unified Theory of Acceptance and Use of Technology (UTAUT), developed by Venkatesh [39], strengthens in particular previous studies on acceptance (e.g. TAM) and considers the behavioral intention as the nearest proxy for the use behavior. According to Verdegem et al. [40], the extension and adaptation of the "adoption determinants" allowed designing a measurement instrument (a survey) that "not only allows to detect different profiles of potential adopters. It also provides valuable input for industry managers about which profiles should be targeted with a specific communication in order to persuade them to adopt the technology." In this case, the objective is always to convince user of the interest of the technology.

"Outflow innovation" and "outflow user" [41] reflect another degree of appropriation. In this case, user extends or distorts the intentions of the original designers. Hacking supports the co-design process.

In a sustainability perspective and the transformation of our society (societal innovation), stakeholders have to share a motivation to serve the public interest and find the balance between economy, environmental, societal and cultural efficiencies. In this framework, designers have to consider the context of use and the environment of the users, such as: links between stakeholders, weak-signals, needs, impacts of the potential innovation, reaction to a new technology or process. By considering the described evolution, LL allows going into greater depth than just a user-centric approach because stakeholders are associated to co-create value. The LL concept seems to be the most appropriate to include usage's complexity when the real-life implementation artifact can support the situational aspects and facilitate product service adoption.

D. Immersion, presence and mock-up

Scholars, within the Constructive Design Research (CDR) [42], [43], Experiential Design Landscapes (EDL) [44] and LL [45] publication streams, have explored the use of prototypes (experience prototyping), usage scenarios (contextual design), scale-models or mock-ups and bodystorming for refining the design of new artifacts whatever is their size. It leads to learn by doing through iterative experiments and continuous evaluation rather than defining artifacts entirely right from the beginning. It also engages people to co-create these artifacts that they will have to interact with. These physical models help answering questions, such as: is it the appropriate size? Will people be able to interact with? Will it properly support social behavior? Will people behave in a safe way? Will it fit with people expectation in terms of user experience?

To support this design approach, LL has to create conditions for experiment as soon as possible in real world. That process could be a big issue in particular for town planning field, due to the size and the duration of the projects. We make the hypothesis that the immersion in experiment, i.e. the capability of mock-ups to put participants in immersion can help users and designers to co-create a new artifact that could be adopted. We think that the more a mock-up put participants in immersion and enhance the level of presence, the more their

reaction is close to the reality. However, which type of immersion is relevant for urban or building project? Furthermore, for users, does the degree of presence influence the feeling to be in the reality? We propose to show in the next section our methodology to validate our hypothesis during the urban research project carried out by our research team.

III. RESEARCH METHOD

A. Contextual details

One cornerstone of the rehabilitation of the Charles III Square (see Fig. 1 & 3) is the setting up of a mobility station that covers several dimensions, such as: collective and individual means of locomotion, public and private transportations, information, advertising, ticket machine, virtual map, etc.

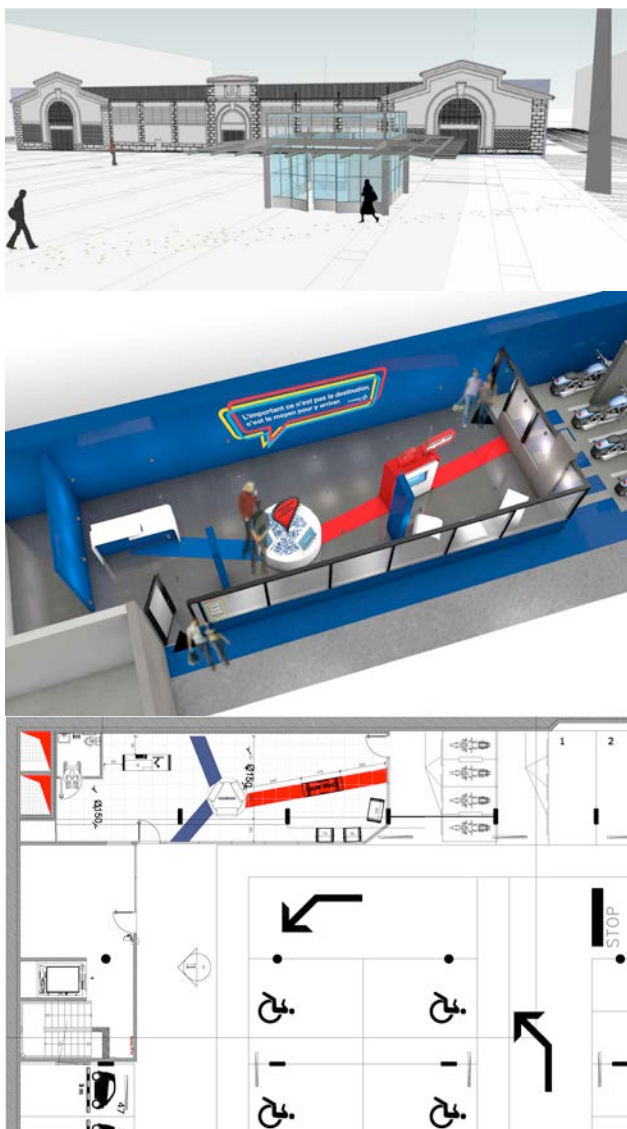


Fig. 3. Mobility station: the kiosk designed by AREP in 2013; Mobiway set up in the basement and the blue-print, both designed by Dragon Rouge in 2013.

The square is one of the nodes in the metropolitan area's transportation network and concentrates various usages, and users with different expectations, which have to be combined in this project. A LL aims precisely to combine these users' perspectives: it focuses on usage expertise, so that users do not need technical knowledge to take an active part in the project, and favors co-created solutions instead of a never-ending debate on ideas. In 2013, local authorities and urban designers chose to work with a company specialized in the building of parking lots and new spaces dedicated to support the city mobility system. The private company sold to the city council a solution named "mobiway" and set it up in the first basement level of the underground public car park under Charles III Square (See Fig. 3). The pedestrian entrance is a specific kiosk. The "mobiway" is a standard product that was created without any contribution from local users and city technicians. In these circumstances, the city technicians of the local authorities made a link with the participatory process of the eco-neighborhood in order to improve the project.

We designed an experiment during the third stage of our planned work with citizens and city technicians. This step is the evaluation of potential solutions as described in the introduction. The first and second stages produce the conceptual knowledge about the usage of the mobility in Nancy. This representation of the reality does not include degree of immersion and level of presence for the user. Thus, we decided to use mock-ups.

B. Experimentation protocol

To lead this research project, we organized a participative workshop with the potential users (citizens and city technicians) of this mobility station. This workshop was set up with an original scenography and a protocol using two specific exercises [46] in order to make sure that user will understand the interest of designing an eco-mobility stations.

1) *Original scenography* [47]: It is the space organization allowing the exhibition of technical views in 3D, blueprints and key-words describing the physical organization of Charles III mobility station and the generic aspects of eco-mobility stations.

2) *Exercice 1 - The scale-model*: it is a spatial prototyping artifact that provides a way to raise issues and respond to the underlying needs of different stakeholders; it is a mock-up with a scale 1:100, measuring 0,25 m x 0,5 m (the scale is smaller than the reality).

3) *Exercice 2 - A bodystorming session* [48]: this method helps to quickly generate and explore many contexts and behaviour-based concepts by physical enactment; this session took place in a real-size room (the full scale of action).

This experiment involved two specialists of focus group (one per exercise) and a group of thirteen participants, divided in two sub-groups: after a presentation of the "mobiway" to all participants and the visit of the exhibition, one sub-group starts working on the scale-modeling while the other takes part in the body storming session; after twenty minutes, the groups alternates. In both exercises participants are asked to "plan the mobility station with the elements you find in the application environment". The mock-up elements and the room elements

are the same, but using different scale: chairs, tables, displays and pieces of paper, Fig. 4.



Fig. 4. Scale-model (left) and bodystorming session (right) (in 2013)

As an indication of immersion and presence fulfillment, the protocol evaluates: the users' ability to project himself in the application environment and the users' knowledge anchorage in the application environment.

C. Data collection

Data from both exercises are collected through a questionnaire to evaluate the interest of each artifact for the project development. The questionnaire contains closed questions, in order to collect quantitative data. Survey asked for example if the path from one exercise to the other helped to enrich one idea formulated in the first exercise? Think about new ideas? Reject one idea formulated in the first exercise? Possible answers were "yes" or "no". These closed questions were completed by a focus group with the following open question: "What did you feel when walking in the scale-model?" "What did you feel during the bodystorming session?" These qualitative data give a better understanding of their perceptions.

IV. FINDINGS

Tab.1 and Tab.2 summarize the answers to the closed questions. Moreover, the answers to the open questions complete the answers to the closed questions. For example, the recurrent answers to the question "what did you feel in the exercise?" are that the scale-model is adapted to develop the generic characteristics of the mobility station and the bodystorming takes into account the experiential aspects (from the user point of view).

Considering the low number of participants, quantitative results are indicative and help to support qualitative interpretations. The main results of this experiment are presented in the following paragraphs.

TABLE I. SUMMARY OF RESULTS FOR THE ORDER: FROM BODYSTORMING TO SCALE-MODEL

Number of participants Answer	7 participants from (A) to (B)	
	Yes	No
Enrichment of idea formulated in A	6 / 7	1 / 7
New ideas generation compared to A	7 / 7	0 / 7
Elimination of ideas formulated in A	4 / 7	3 / 7
Complementarity of A and B	7 / 7	0 / 7
Preference of A and B	3 / 7	4 / 7

(A) = Bodystorming and (B) = Scale-model

TABLE II. SUMMARY OF RESULTS FOR THE ORDER: FROM SCALE-MODEL TO BODYSTORMING

Number of participants Answer	6 participants from (B) to (A)	
	Yes	No
Enrichment of idea formulated in A	5 / 6	1 / 6
New ideas generation compared to A	4 / 6	2 / 6
Elimination of ideas formulated in A	2 / 6	4 / 6
Complementarity of A and B	6 / 6	0 / 6
Preference of A and B	3 / 6	3 / 6

(A) = Bodystorming and (B) = Scale-model

A. Full size scale model better supports user's immersion

According to the participants, bodystorming is adapted for "bodily experiences". They say that it makes easier to visualize the mobility station "from the user point of view" compared to the scale-model. The groups quickly develop various usage scenarios that evolve while experiencing them physically. Some planning problems appear after exploring solutions from the mock-up in real-life scale. For example, if the automatic tickets distributors are too close to the door, the queue in front of these distributors could obstruct the entrance and the exit. Furthermore, the participants that express a mock-up artifact preference orient their choice toward the bodystorming, because of its ability to "immerse people in the space".

The scale-model is rather perceived as a way to "generate ideas without material constraints". It focuses more on "the concept and the spirit" of the space and less on the "practical and functional" planning. This scale-model artifact is used to get a "global view" of the initial problem.

According to our results, the scale has an impact on users' ability to project themselves in the application environment: the closer to the real life environment the physical size is, the easier it is for the users to project usages in the application environment.

B. Generation of user's knowledge

The scale-model artifact supports "ideas generation and creativity". As a second exercise, scale-model is more effective to generate new ideas (7/7) than bodystorming (4/6). In contrast, two of the six participants that tried scale-model first and then bodystorming stated that bodystorming did not add new ideas. This finding leads us to say that the scale model favors idea generation, and that it seems not necessary to experiment bodystorming to generate new ideas after it. However, we must confirm this result.

The bodystorming helps to support "ideas' exploration and selection". It is a good method to "understand the others' point of view" and to co-create solutions that fit the participants' expectations and the spatial constraints.

The participants think that both exercises are highly complementary. The path from one exercise to the other, whatever the order, favors ideas enrichment (for 6/7 of the participants from the first group and 5/6 of the participants from the second one). It highlights also the importance of combining exercises for the project process. Both exercises generate different types of users' knowledge. Scale-model is more adapted to the ideation phase while bodystorming fits

better the co-creation phase. The environment scale has an impact on the type of users' knowledge that could be collected: the closer to the real life size the environment is, the more anchored in the application environment the collected users' knowledge is. Working on a mock-up is not enough to get reliable data on which to build the space planning, it is necessary to confront the planning ideas to a realistic environment.

The environment scale has effects on users' projection ability and on users' knowledge. We conclude in this specific experiment context that mock-ups positively impact the degree of immersion and the level of presence. The experiment shows that user's physical immersion in the application environment favors the realistic perception of the usage situation and the co-creation of an artifact.

C. Operational findings for town-planner

It is not necessary to be in real conditions of use throughout the project to collect reliable data. When the situation seems realistic to the users, they can visualize potential usages and express feedbacks. Nevertheless, the confrontation with the real environment is a true advantage to reduce the risks of misinterpretation (Interpretation of the potential users, the researchers and finally the decision-makers).

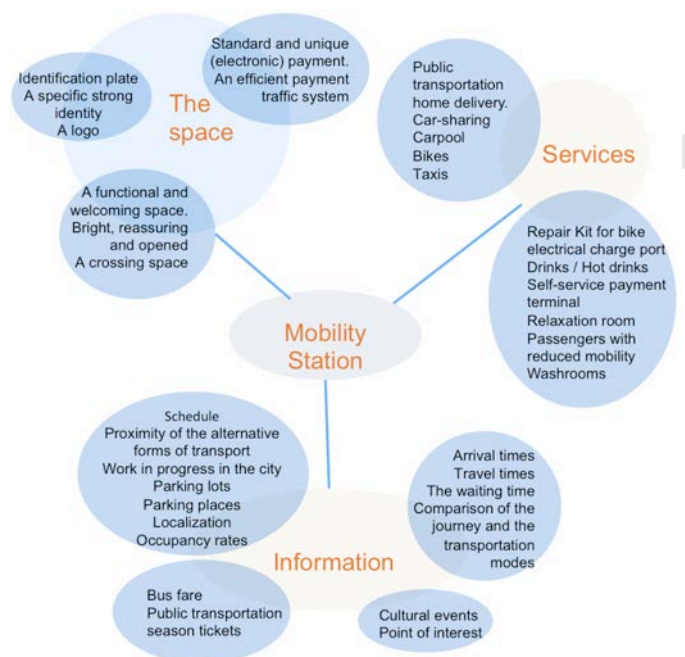


Fig. 5. Generic characteristics of the mobility station suggested by the participants

Based on physical representations and first usages, this experiment materializes and evaluates results from the first and second stages of the global research project with LL approach. We gathered all these results in a technical report for the territorial engineers and the elected representatives. According to our co-design process support by LL and mock-ups, the

generic characteristics of a mobility station for the urban area of Nancy are built around three key elements such as: the space, services, and information (see Fig. 5).

We also asked to the participant to localize mobility stations on a layout of the urban area (see Fig. 6). The users expressed the stations could be set gradually up and it might be interesting to adapt the characteristics to the location (Tab. III).



Fig. 6. Localization of the potential mobility station (in 2013)

The panel suggests the territorial engineers set up two or three very elaborate stations in the city center, indicating the points of interest or the places to be visited and the means of locomotion to reach there. The mobility stations outside the city center or at the entrance of the urban area might be "park-and-ride facilities".

TABLE III. USAGE EXPRESSION FOR MOBILITY STATIONS

Urban scales	City center	Urban area	Outside the urban area
Services	Public transportation		
	Carpool		
	Car-sharing		----
	Self-service bikes	Secure parking lot for bikes	
	Taxis	----	
Function	Home delivery		
	Self-service payment terminal		
	Real-time information system (with available services)		
	Infrastructure for charging electric and hybrid rechargeable vehicles and bikes		
	Accessible for passengers with reduced mobility		
	Relaxing room		
Repair kit for bike			
Washrooms			
Hot-drink machines			

Furthermore, the proposals of adjustment of the programed implementation of mobility station consolidate the urban project design. This experiment is a brick in a global citizens' involvement in the urban design process. This approach allows bringing together the different stakeholders of the city, sharing knowledge and make smarter the urban project and the city.

D. Summary of the results

Tab. 4 gives the auto-evaluation of our experiment. The evaluation is based on the highest observed level. "+++" is the highest level. "o" means insignificant.

TABLE IV. USAGE EXPRESSION FOR MOBILITY STATIONS

For users	Degree of immersion	Level of presence	Knowledge
1- Digital model and blueprints	o	o	Learning from engineers and companies
2- Mock-up	+	+	Ideas generation and creativity
3- Bodystorming	++	++	Understand the others' point of view / share knowledge
4- Localization	o	+	Adjust / make both robust and effective
Mix approach: 1+2+3+4	+++	+++	Co-create a new artifact and test some characteristics

V. CONCLUSION

The present paper focuses on an experiment in the context of an urban project dedicated to the design of mobility stations that reveals the paramount importance of the mock-up role for implementing real-life situations. The findings unveil the great potential of close-to-real-life immersion of users/citizens in realistic environments to not only fulfilling the real-life principle of LL but also greatly contributing to the adoption by users/citizens. For example, our empirical study provides identification of functional answers and optional development adapted for the needs of users. These characteristics already do not exist in the first mobility station. Furthermore, the experiment allows forecasting the set up of the mobility station in the first basement of the parking lot will restrict its use.

The state-of-the-art crosses references from the LL concepts, user-centered design, innovative process and interaction with real artifact. This logic allows building a framework of hypothetical operation around mock-ups. Thus, this study gives some elements to support citizens' engagement in the co-creation stage of the urban design process towards the realization of smart-cities. Indeed, when the real-life implementation artifact supports the situational aspects, we are able to include usage's complexity of one urban project. We highlight the role of mock-ups in the anticipation of the UX within a LL. This hypothesis was validated in two different application environments, in a project of mobility station planning. The first environment was a scale-model, with which hands allow physical immersion; the second was a room adapted to the dimensions of the future mobility station, offering then the possibility to the participants to immerse in the environment. This experience tempts researchers to conclude that the closer to the real life size the environment is, the more inspirational the usage situations are to support users co-creation; our hypothesis is then validated in this specific case. The empirical material used, as basis for the validation, is a first step and can be improved later on. The role of mock-ups must be experimented in other projects, within other specific contexts, other people and other LLs. Several up-coming urban and industrial projects will permit to further explore the potential of different mock-up artifacts.

Generating real-life immersive environments and an appropriate degree of presence for potential users in urban projects remains a challenge. The usual working habits of the territorial engineers or town-planners are not prepared for.

Further developing a specific LL method that is easy to realize and appropriate for the various stakeholders would be necessary. The next step would be to evaluate the potential adoption of the proposed type of experiment among different LLs in the network and other urban projects involving users and territorial engineers. Indeed, it is crucial to make this constructive design method robust enough in order to bring the best solutions to the social and societal stakes of the smart-cities.

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