Design and prototyping of an interactive virtual environment to foster citizen participation and creativity in urban design

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Abstract

Public Participation encounters great challenges in the domain of urban design concerning decision making and citizens' appropriation of a future place. Many tools and methods have been proposed to ease the participation process. In this paper we are targeting artefacts used in face-to-face workshops, in which citizens are asked to make design proposals for a public space. We claim that current state of the art can be improved (i) by better articulating digital artefacts with participatory processes and (ii) by providing interfaces that enhance citizen's spatial awareness and comprehension as well as collective creativity in urban design projects. We present the design and prototyping of an interactive virtual environment that follow the design-science research guidelines.

Keywords: ICT-enabled citizen participation, co-creation, urban design, interactive virtual environment, design-science

1.   Introduction and context

Public Participation (PP) has imposed in the last decades as one of the key factors of successful urban design and development projects. Lack of communication and collaboration between citizens and urban design experts can generate conflictual situations, leading to substantial delays and cost overheads, and eventually to project cancelation and political crisis as in Stuttgart 21[1], Notre-Dame-des-Landes[2] or EuropaCity[3] projects. To summarize:

> *"Design is not just for designers and their acolytes. Urban design, like all*
>
> *design, should involve a dialogue with the customer, whether the existing*
>
> *people within an area or those likely to move in. "* [43], (p. 11)

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[1] https://en.wikipedia.org/wiki/Stuttgart_21

[2] https://fr.wikipedia.org/wiki/Notre-Dame-des-Landes

[3] https://fr.wikipedia.org/wiki/EuropaCity

The stakes of these projects are generally too critical to leave citizens voices apart. Urban designers and local authorities should not forget end users when designing public places in order to respect their quality of life and their 'ownership', in the sense of [26], whom define it as *"the right to act upon an issue…, a sense of belonging to a collective place"* (p. 94). Moreover, in most European countries, participatory processes are mandatory in urban projects aiming to modify the living environment of citizens, in line with the Aarhus Convention[4] and Council of Europe Recommendation 1430 (1999)[5]. As a result, a vast number of methodologies and toolkits have been developed lately, applicable to different steps of urban design and planning projects. Among these methodologies, an increasing number are focused on ICT-mediated PP in urban issues, which are: *"technology being addressed in such areas as governance, urban planning, information systems and interaction design, geography, citizen activism and community development"* [32] (p. 1). The ambition of an ICT tool for urban design is to provide a digital interface between experts and citizens to let them collaborate and benefit from each other's knowledge.

Urban design is a process that aims to define the shape of a city, district or public place and connect it to the surrounding environment (people or nature). It defines the spatial configuration and functionalities of a future urban area, but also considers civil society needs and financial aspects to define an attractive and sustainable area. The term urban design is different from urban planning which is a long-term process concerned with urban development, for instance land use plans, environment protection, infrastructures for transportation or job creation strategies. In other terms, urban planners diagnose macro-problems and urban designers manage to solve those problems.

Public authorities can decide to apply a certain degree of citizen involvement in the decision-making process. [40] divided the urban design process in four different steps: initiation, planning and design, implementation and maintenance. For each of these steps, citizens can be highly involved in the process and work in autonomy, or just be informed of the decisions without being consulted. The four different degrees of involvement are, from lowest to highest: information, consultation, collaboration and autonomy. This paper will be focused on design and prototyping of a digital artefact to enhance collaborative and creative design. More particularly, we consider face-to-face creative participatory sessions in which professionals and citizens work together to define the future of a public space such as a public park. We'll also pay attention to the definition of a process facilitating collaboration and co-creation of urban design proposals, and its articulation with the digital artefact.

The paper will be organized as follows. Section 2 will review existing literature and identify eventual gaps. Section 3 will present the research approach. Section 4 will present the main results: a process for collaborative and creative PP in urban design (4.1), specifications of a digital artefact rooted in field observations (4.2), and software architecture as well as user interfaces of a first prototype (4.3). Section 5 will discuss the results and presents direction for the future work. Section 6 will conclude.

2.   Literature review

During the last decade, a large variety of methods and tools has been proposed to facilitate PP in urban design and planning [40]. Most of those tools traditionally rely on materials such as printed images, printed 2D maps, prepared 3D models, foam, pencils and paper. More recently, effort has been made to benefit from the advances in computer-aided tools to enhance citizen's interaction and engagement in the decision-making process [4]. We selected

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[4] 1998 UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, adopted by the fourth "Europe for Environment" conference in Aarhus, Denmark, on 25 June 1998.

[5] Council of Europe Recommendation 1430 (1999) of the Parliamentary Assembly on access to information, public participation in environmental decision-making and access to justice

publications published between 2004 and 2018 that address the topic of a 3D artefact supporting PP in city making process.

Many research project have demonstrated the value added of digital 3D environments for citizen participation [1–4, 18, 27, 41].This new form of interaction helps participant to better understand the future of a place and support dialogue.

Based on the reviews presented by [8],[23] and [19], we can conclude that most of existing tools are focused on 3D visualization and feedback, which fall into information and consultation degree of participation according to [40]. That is, participants can only see professional proposals, give a feedback, or vote for a design proposal.

Few papers are eager to provide a higher degree of participation, namely collaboration and co-creation. In other words, efforts to define a digital artefact helping non-professional participants to express their ideas through the creation of urban design proposals can be increased. Such artefact shall also enhance collaboration between citizens and experts. A citizen-made design proposal shall be used to inspire urban design experts, so they can create comprehensive designs that take into account citizens opinions. As a result, such professional designs are more likely to be accepted.

The second observation of the reviews is that there is a divide between two main areas of research. Research led from Urban Studies standpoint generally defines PP processes and discusses eventual impacts of ICT-mediated participation, without implementing a digital artefact or considering eventual technological gaps [22–24, 32, 38, 39]. On another hand, research led in Information Systems or in Computer Science fields presents a digital artefact without taking into account its articulation around a participatory process, or without rigorous knowledge of the studied environment [9, 10, 36, 42, 44, 13–16, 25, 28, 34, 35]. Furthermore, the above-mentioned contributions mainly propose solutions falling into the space of urban planning, not urban design.

A tentative to address either urban design processes and the artefact design is [29], which describes *"a new strategy of urban design with the purpose to overcome the technological perspective of current urban planning methods towards a participatory planning approach"* (p. 187). However, the paper neither presents specifications and evaluation of the tool, nor its articulation with a participatory urban design process. The main function of the tool is to let users explore an urban design scenario, by changing position of 3D objects, or rotate them. Additionally, objects cannot be edited in terms of geometry, which limits creativity of participants. Moreover, this web tool is well adapted for massive participation but does not cover face-to-face workshop settings. The latter is usually facilitated in a manner to allow direct interaction, collaboration and co-creation between citizens and professionals and thus lead to more qualitative and comprehensive results. The analysis made by [19] confirms our diagnosis: *"The projects verify available technical possibilities and do not match real actions connected with social participation in planning [...] Most of examples show how computer tools may be used for visualizing the new development and not for constructive process of continuous public participation"* (p. 303).

Research problem

To address the identified gaps -lack of collaboration and co-creation tools, articulated around a well-defined participatory urban design process- we are eager to design and prototype a digital artefact to foster collaboration and creativity in urban design projects. The artefact will be tailored to the settings of face-to-face workshops gathering professionals and non-professionals. Furthermore, it will be designed considering the essential rules and steps of a benchmarked PP urban design process. Finally, we aim at using cutting-edge immersive and interactive interfaces for the prototype instantiation.

3.   Research approach

In order to bridge the approach from Urban Studies with that of Computer Science and Information Systems, while addressing the complexity of the Environment, design-science [20] seems to be an appropriate methodology.

Methodological framework

In line with the guidelines of design-science research [20] to design, develop and evaluate the immersive collaborative digital artefact, we consider both the Environment of the research problem and its Knowledge Base. The study of the Environment, namely citizen participation in urban design, brings information about problems and needs of end-users and will help us to derive relevant functionalities afforded by virtual environment. To ensure research rigor, we build on the current state-of-the-art empirical contributions, available methodologies and place our research in a well-defined epistemological tradition. Figure 1 synthesizes the way our research is conducted. Environment analysis and Knowledge Base study feed the design, development and evaluation phase. Iterative development loops enable us to refine the digital artefact to bring it to the Environment. During the iterative design, development and assessment we are able to theorize the IT artifact [31] to further feed the Knowledge Base.
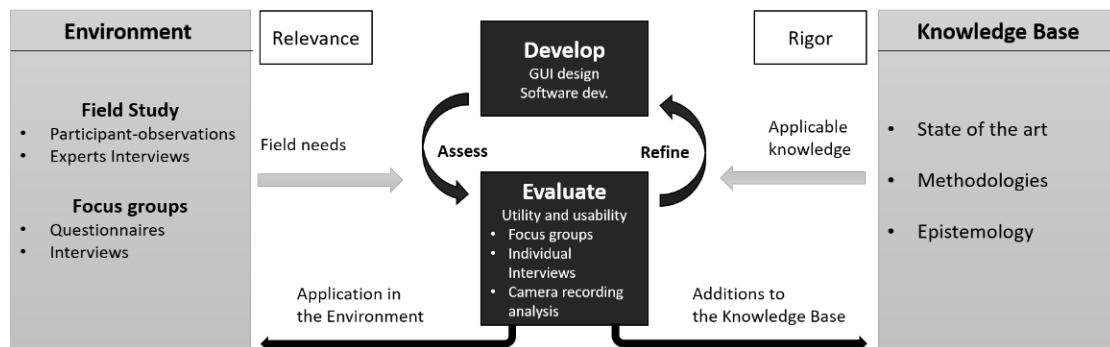

Figure 1: Research approach overview inspired by design-science research [20]

Epistemological position

Since the design of the digital artefact draws on study of humans within their social setting and on their experiences and interpretations, interpretivist epistemological stance and qualitative research seem to be well-suited for our research problem [17, 30].

Environment

Our research project is informed with longitudinal observation of a participatory design process of an urban par, as a part of a large urban renewal project in Marseille from April 2016 to March 2018. We adopted an ethnographic approach to discover the facilitation process and study in situ interactions between citizens and professionals during participatory workshops. We engaged in overt participatory observation to become familiar with participants and the place and understand individual and collective issues at stake [11, 12]. In addition, we had an opportunity to run ethnographic observations of a participatory design of a sport and cultural community area near Marseille in March 2018. We combined the direct observations with in-depth semi-structured interviews of professional urban designers and planners to collect rich data. The ethnographic study of the participatory workshops offered an enriching empirical perspective that helps to understand the process of collective sense-making, creative expression and negotiation of the future of the place. It uncovers the role of facilitation methods that support these collective processes.

Last, to deepen our understanding of how participants engage with make tools [33] to express their ideas about the future of a place, we organized two simulations of participatory design workshops. We complemented our direct observations with semi-structured interviews with the participants of the simulations.

Data collection and analysis

Our research design rests upon a variety of data sources including: (1) participant-observation of participatory urban design workshops; (2) interviews with professionals; (3) simulation of

participatory workshops; (4) interviews of the participants of the simulations; (5) reports from the participatory workshops of the design of the public park in Marseille.

We started the investigations by attending the participatory workshops in Marseille. We were active at the workshops and interacted conversationally with various workshop participants: residents, activists, representatives of local associations, etc. We took photographs and notes during the participatory sessions. In a first phase, we interviewed the facilitator of the workshop, a person in charge of relations with citizens, and a professional urban designer managing the design of the park. We attended an alternative event focused on the future design of Marseille organized by city activists and interviewed the leader of the initiative. We triangulated this data with information about the urban renewal project of Marseille collected on Internet (press, blogs, social media).

In order to place the participatory design of the park in a broader professional practice context, we run semi-structured interviewed with two professional urban designers and a creative facilitation professional.

To obtain more information about collective creation practices and processes during participatory urban design workshops we conceived and run two simulations of co-creation workshops. The objective of the simulation was the same as that of the real workshops, envision together the future of a public space. The facilitation process borrowed the steps of the design of the park in Marseille, and an additional step was added asking participants to craft their own design proposal with make tools (see Figure 2). Each simulation workshop gathered 5-7 participants. They had diverse profiles: knowledge of urban design ranging from non-professional to professional level, knowledge of digital technologies ranging from beginners to skillful users, age ranging from 20 to 60 years old, half of them were female. Building on the analysis of the simulation workshops, we defined a list of questions for semi-structured interviews of the participants and interviewed them.

The simulations were video recorded. The interviews were recorded and transcribed. Quotes have been translated from French to English for this paper.

This research design, combining observation of real participatory urban design workshops, simulations and interviews enabled us to gather rich data. A thematic content analysis of the collected qualitative data was conducted with NVivo software (version 10). Following the inductive qualitative method [5], we generated representative units and categories of analysis of the phenomenon from the environment data. We can thus shed light on the collective negotiation and co-creation processes during participatory workshops. We can describe how boundary objects support these collective processes [33]; and derive requirements for design and development of the immersive interactive digital artefact.

We are convinced that this methodological approach, mixing the analysis of real case studies and simulated scenario workshops, with feedbacks from professionals of urban design, supplemented with our observations, is particularly suited to the research problem.

Software Development Process

The development-evaluation loop rests on the agile methodology spirit[7]. We currently implemented a first version of the prototype and plan to evaluate its utility and usability following the guidelines of [6]. Each future version of the prototype will take into account user feedback (citizens, urban design professionals, immersive and interactive technologies professionals, etc.) gathered during the evaluation phase.

The benefits we see in the design-science approach are flexibility regarding the specification of the artefact, through repeated user tests, which result in the end in a user-defined software meeting the needs of the Environment; and a meaningful contribution to the Knowledge Base for future work.

4.   Results

4.1.   A process for collaborative and creative PP in urban design

A participatory process to support collective negotiation

Participant-observation of the early design phase of the urban park in Marseille enabled us to identify a generic sequence of participatory workshops to ensure citizen's expression, negotiation, consensus finding, and a convincing translation between expert's and citizen's language. Figure 2 illustrates the different stages starting from (1) the analysis of the current state of the place, followed by (2) an ideation session without spatial constraints, and finally (3a) refining of the previous step by spatially positioning the ideas. The results are used to feed professional work (4). Each step can be composed of several workshops and the global sequence can be repeated iteratively, as many times as needed.

For example, in the project under observation there were two iterations, each composed of five workshops. The first iteration was to establish global specifications about the atmospheres and features of the park, along with the definition of separate zones. It resulted in the definition of requirements, and a competition to select an urban designer team proposing the most suited solution. The second iteration, involving the winning team of urban designers, was to define precisely the content of each zones and assess a final professional design proposal. The tools proposed to citizens during the different workshops were limited to 2D printed maps, printed images representing global features and atmospheres of public parks, pencils, post-its, scissors and printed questionnaire templates to give feedback.

The analysis of the collective negotiation process enables to derive an initial set of requirements for the definition of a digital artefact:

   a) Reading of scales and distances must be easy
   b) Possibility to define zone with associated surfacing, atmosphere, uses and street furniture
   c) Transparency about technical, political and financial constraints
   d) Precise definition of zones opened to collective negotiation, and zones not opened to public discussion due to technical, financial or other constraints
   e) Necessity of a very rich library of visual representation of atmospheres, uses and street furniture, to unlock participants' imagination.
   f) Expert's proposals should not be communicated too early not to lock participant's ideation
   g) Expression of local knowledge (culture, uses of the place, heritage, history, …) needs to be facilitated
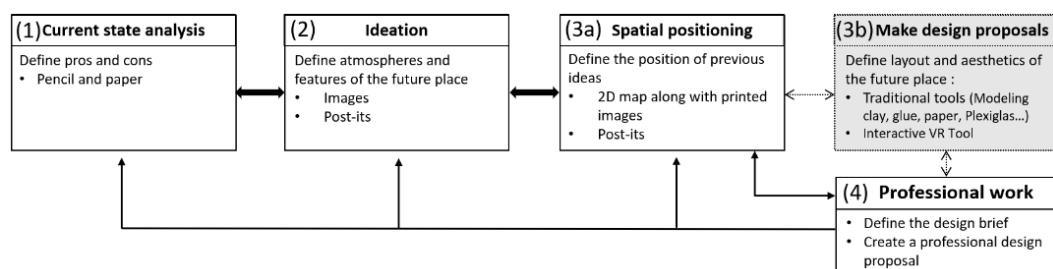

Figure 2: Participation process inspired by the field observation. Dotted gray square highlights novelty from the observed process.

The participant-observation lead to the conclusion that creativity of participants can be further enhanced. The use of printed images certainly fed the expression of participants by means of various combinations of atmospheres and furniture. Nevertheless, current literature on co-creation highlights the need to improve the process by integrating the use of make tools [33].

Towards creative workspaces

Make tools support citizens' creativity by enabling them to express their latent and tacit level of experience, in addition to explicit and observable knowledge that can be expressed with words. To access the explicit layer, well-known narration and visualization techniques are sufficient (the ones used in the observed urban design project). To access the tacit and latent level of knowledge, people should manipulate objects. This implies the integration of a new step (3b in Figure 2) in the observed process with the help of make tools, focused on the creation of urban design proposals by citizen. Most used tools to achieve this step are 'pencil and paper' tools, meaning participants manipulate paper, scissors, glue, cardboards and pencils to represent elements such as a house, a fountain, basketball field, etc.

In order to identify additional requirements of the digital artefact and better understand how people express with make tools, we organized two simulated scenario workshops relying on traditional tools. The process embraced steps from (1) to (3b) in Figure 2.

By analyzing the camera/audio recording as well as the individual post-workshops interviews, we derived the following additional requirements:

    h) Participants need a way to add contextual information in order to locate themselves and get a better understanding of the place

    i) Participants need to have access to different types of materials/ground surfaces

    j) Participants need to see reliefs on the map

    k) Proposed prefabricated objects must be on scale

    l) Participant need common objects to better understand spaces (a bus, a bench, a football field...)

We intend to support the presented process with the help of an interactive and immersive environment that will embrace requirements a) to l).

4.2. Specifications of a virtual environment for PP in urban design

In this section we define the specification of a digital artefact meeting the process and requirements presented above (Section 4.1). Based on field observations, we assume most users will have low skills in software manipulation and a good awareness of urban design constraints. Hence, using this artefact, a user (expert or amateur) shall be able to easily create a design proposal and associate information to it. Moreover, professionals need an interface to extract useful information from citizen's ideas and implement professional design proposals. Therefore, we propose to divide the artefact in 3 different workspaces: a creation workspace, a visualization and feedback workspace and a professional workspace.

Creation workspace

This workspace is the transposition in a virtual environment of a traditional creative workshop using prepared 3D models (basic shapes and city furniture), pencil and paper. We define it as an interactive virtual environment where users can work in collaboration. This means that multiple users can interact with the interface concurrently, as they would do around a 2D map. The workspace is representing the future construction zone of the project with surrounding streets and infrastructures represented in 3D, with a predefined scale. To manipulate the environment, users are given multiple tools:

- A categorized 3D model database. The categories may be straightforward as "houses" or "bridges" but also grouped by more abstract keywords as "Asian style garden" or "games for children".

- A creation toolbox, which is the virtual representation of the manual actions used in standard creative workshops (hands manipulation to rotate, move, cut, assemble) and additional actions as 3D model scaling, cancel previous action, save current work.

- A configuration toolbox allowing to add constraints and information to the workspace. For instance, define unmodifiable zones, associate metadata to objects or associate behaviors to preselected zones.

In other terms, this workspace can be seen as multiple layers with associated interactions. The first layer is a map with streets and infrastructure. The second layer gathers additional 3D

models and constraints assigned to the first layer. The layer contains sematic information associated to the previous layers.

Visualization and feedback workspace

This is the place for immersive visualization and support of decision-making. The aim is to let the user explore its design proposal in a 1/1 scale, to fully understand the impact of his/her work and feel the atmosphere of the place. This workspace shall be used iteratively with the creation workspace to refine the design proposal. In this workspace, no modification of the current work is possible, the user can only explore the place and associate feedbacks or comments to specific zones.

Professional workspace
This workspace allows professionals to visualize and analyze citizen's proposals and access feedbacks gathered during workshops. From this interface, they also have access to management features regarding 3D data, users and process. The aim is to help them in decision-making and inspire their future work.

4.3.   Software architecture and user interface

Figure 4 presents the software architecture of the interactive and immersive artefact, which rests on Unity3D software along with a touch table and a head-mounted device. Unity is a widespread game engine which can easily support 3D visualization and interaction definition by scripting, and is well suited for an urban design tool [21]. The usage of table for the creation workspace seems well-suited to engage discussion and exchange ideas. It supports a circular configuration of multiple subgroups [28], collaboration and parallel problem solving [37]. Well-defined tactile interactions offer a more fluid and intuitive experience than the combination of a mouse and a keyboard [37]. Therefore, we chose to build a touchscreen-based solution for the creation workspace ((1) in Figure 4). Moreover, we believe this technological choice is the best suited to support collective creativity in urban design compared to the solution of augmented reality and tangible interfaces [9, 35, 44, 45] that mainly support collective negotiation.

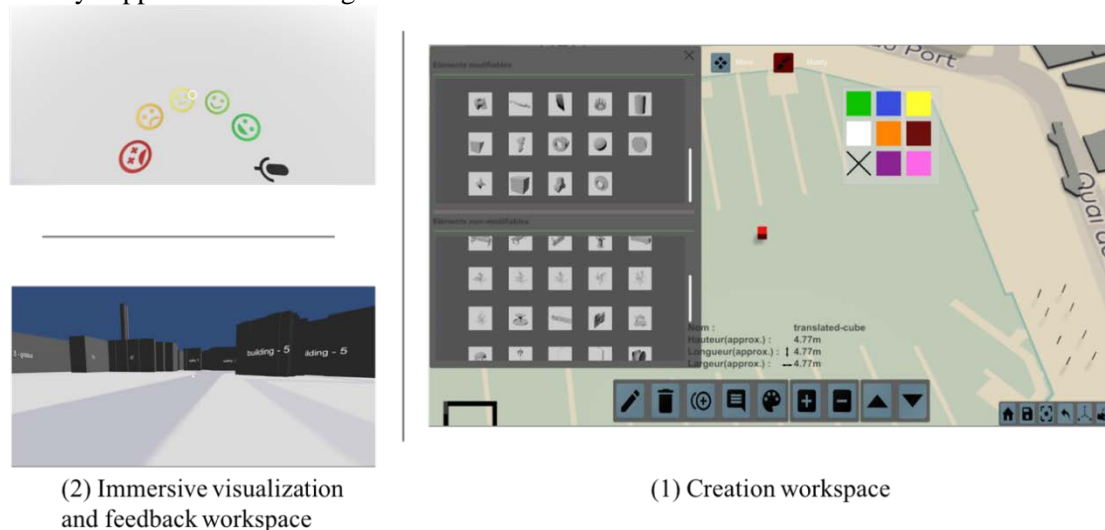(2) Immersive visualization   (1) Creation workspace
and feedback workspace

Figure 3: Snapshots of the different workspaces

To generate the initial map along with streets and infrastructures, we use a Unity plugin called MapBox, which gathers data from the Open Source platform OpenStreetMap to generate a 3D environment with the provided geocoordinates. Image (1) of Figure 3 illustrates the user

interface developed with Unity3D editor. The camera point of view is a bird-eye view. From this interface, a user has access to the following interactions:

- Move camera (one finger drag)
- Zoom camera (two fingers)
- Select/unselect object (double tap)
- Move a selected object (one finger drag)
- Scale a selected object (two fingers pinch)
- Rotate a selected object (tree fingers drag)
- Edit a selected object: edition consists in slicing a 3D element in two different parts. To do so, the user need to draw a line over the model to extract the desired part.

To implement the slicing operation, we developed a C++ plugin using CGAL Open Source library ((4) in Figure 4), which receives as input two *.off* files: the model and the line drawn by the user and two transformation matrixes extracted from Unity. The plugin then returns the two slices of the object.

Additional interactions are available through touch buttons: delete, duplicate, change color, change metadata (title and description) of a selected object. The user also has access to a 3D model database, allowing to add additional elements to the environment. Finally, each user can save its work in order to continue later if needed.
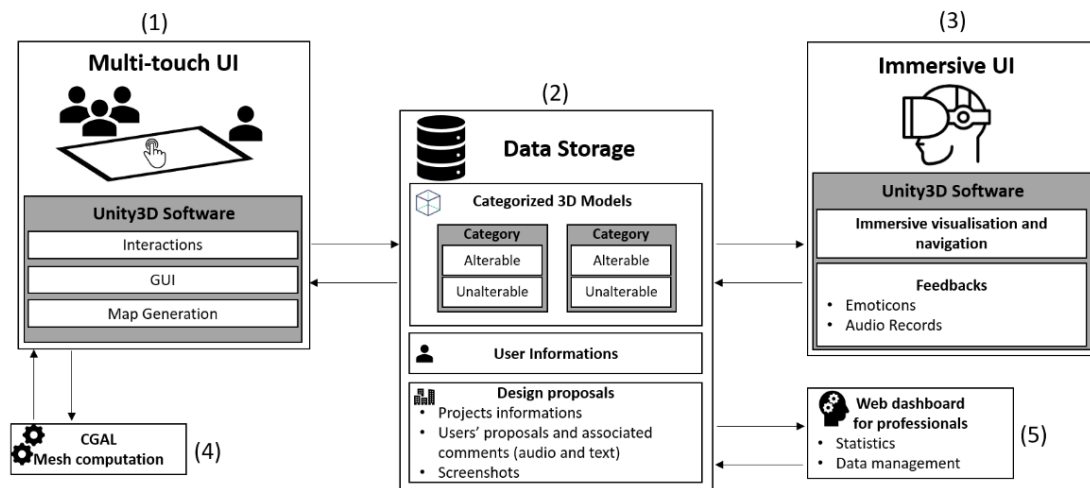

Figure 4: Overview of software architecture

To instantiate the immersive visualization workspace ((3) in Figure 4), we propose to use a Head Mounted Display, such as a low-cost cardboard or a high-end device as an HTC Vive. Our prototype uses a Cardboard, hence we are currently limited with interactions. Through this environment ((2) of Figure 3), a user can explore his/her or someone else's proposal, either with an 1/1 scale view or with a bird-eye view. The available interactions are only feedback actions:

- Associate an emoticon to a selected object
- Associate an audio record to a selected object

The professional workspace ((5) in Figure 4) is accessible via a web interface, as presented in the third image of Figure 3. From this interface a professional can study all feedbacks, in the form of emoticons or audio recordings.

Finally, all the data (3D models, User information and saved Design proposal) are stored in a file architecture ((2) in Figure 4).

5. Discussion and future work

To situate our contribution with respect to identified literature (presented in section 2), we compare our work against 8 criteria defined on the basis of the requirements a) to l) (Section 4). Each criterion contains a needed characteristic for the definition of a collaborative ICT

tool for PP in urban design. Table 1 provides an overview of each criterion with associated characteristic and requirement.

Criterion number	Definition	Supported characteristic(s)	Associated requirement(s)
1	Reconstitutes the surrounding area of the future place: streets, buildings, contextual information (street names, building names, …)	Spatial awareness and comprehension	a), c), d), j)
2	Offers the opportunity to explore the future place with bird's eye view (zoom in/out, move camera)	Spatial awareness and comprehension	a), c), d), j)
3	Offers the opportunity for immersive visualization (scale 1:1 with a Head Mounted Display)	Spatial awareness and comprehension	a), c), d), j)
4	Offers the opportunity to annotate/categorize 3D elements (metadata)	Idea expression and feedback	g), h)
5	Offers the opportunity to manipulate 3D elements (move, scale, rotate, delete, change color/material)	Idea expression and feedback, Creativity	b), e), i), l)
6	Offers the opportunity to add new 3D elements in the virtual site (both abstract and complex shapes)	Creativity	e), k), l)
7	Offers the opportunity to edit 3D elements: cut and assemble	Creativity	e), l)
8	Offers an interactive and collaborative interface via touch screen	Collaboration, Co-creation	a)

Table 1: Comparison criteria derived from the analysis of the Environment

Table 2 shows our differentiation compared to the state of the art. The comparison clearly highlights that little attention is payed to co-creation by providing necessary tools, metaphors and interactions (criteria 5 to 7). The proposed artefact fills this gap. Furthermore, compared to the majority of the contributions in Computer Science and Information Systems, we are placing the artifact in articulation with a well-defined participatory process.

Reference	Criterion number							
	1	2	3	4	5	6	7	8
[34]	N	N	P	P	N	N	N	N
[29]	P	Y	N	N	P	P	N	N
[25]	Y	Y	P	Y	Y	Y	N	N
[42]	Y	Y	P	Y	N	N	N	N
[16]	N	N	N	Y	N	N	N	N
[13]	P	Y	Y	N	Y	P	N	N
[28]	Y	Y	N	N	N	N	N	Y
[15]	N	Y	Y	N	Y	Y	P	N
[10]	N	N	P	Y	Y	P	N	N
Our artefact	Y	Y	Y	Y	Y	Y	Y	P

Table 2: Evaluation of existing artefacts for public participation in urban design. Y: criterion is respected, N: criterion is not respected, P: criterion is partially respected.

Our future work will be focused on a qualitative and quantitative evaluation of the artefact through simulated scenario workshops and real situation workshops. We'll also follow the guidelines for collaborative interfaces from literature since our prototype doesn't fully respect yet the multi user interactions (criterion 8). Finally, we'll deepen our work on data extraction and visualization for professionals.

6. Conclusions

In this paper we presented the design and software architecture of an interactive virtual environment to support citizen participation and creativity in urban design. We payed

particular attention to define an artefact intended for face-to-face workshops, helping citizens to creatively express their explicit and latent expectations of future public spaces. The advantage of our contribution is to bridge knowledge from urban design field about participatory processes and knowledge from Computer Science and Information Systems fields about digital artefact design. We built our solution considering current advances in immersive and interactive technologies such as touch screens and head mounted displays.

Acknowledgements

References

1. Al-Kodmany, K.: Combining Digital and Traditional Visualisation Techniques in Community-Based Planning and Design. Digit. Creat. 10 (2), 91–103 (1999)
2. Al-Kodmany, K.: Public Participation: Technology and Democracy. J. Archit. Educ. 53 (4), 220–228 (2000)
3. Al-Kodmany, K.: Using visualization techniques for enhancing public participation in planning and design: process, implementation, and evaluation. Landsc. Urban Plan. 45 (1), 37–45 (1999)
4. Al-Kodmany, K.: Visualization Tools and Methods in Community Planning: From Freehand Sketches to Virtual Reality. J. Plan. Lit. 17 (2), 189–211 (2002)
5. Allard-Poesi, F., others: Coder les données. Conduire un Proj. Rech. une Perspect. Qual. 245–290 (2003)
6. Assila, A.: Une approche et un outil pour l'évaluation subjective et objective de l'utilisabilité des systèmes interactifs : application à un système d'aide à l'information voyageurs. (2016)
7. Beck, K., Beedle, M., Bennekum, A. van, Cockburn, A., Cunningham, W., Fowler, M., Martin, R.C., Mellor, S., Thomas, D., Grenning, J., Highsmith, J., Hunt, A., Jeffries, R., Kern, J., Marick, B., Schwaber, K., Sutherland, J.: Manifesto for agile software development. (2001)
8. Billger, M., Thuvander, L., Wästberg, B.S.: In search of visualization challenges: The development and implementation of visualization tools for supporting dialogue in urban planning processes. Environ. Plan. B Urban Anal. City Sci. 44 (6), 1012–1035 (2017)
9. Broll, W., Broll, W., Lindt, I., Ohlenburg, J., Wittkämper, M., Yuan, C., Novotny, T., Fatah gen. Schieck, A., Mottram, C., Strothmann, A.: ARTHUR: A Collaborative Augmented Environment for Architectural Design and Urban Planning. JVRB - J. Virtual Real. Broadcast. 1(2004) (1), (2004)
10. deVries, B., Tabak, V., Achten, H., De Vries, B.: Interactive Urban Design using integrated planning requirements control. Autom. Constr. 14 (2), 207–213 (2005)
11. DeWalt, K.M., DeWalt, B.R.: Participant observation: a guide for fieldworkers. , Walnut Creek (2002)
12. DeWalt, K.M., DeWalt, B.R.: Participant observation. In: Bernard, H.R. and Gravlee, C.C. (eds.) Handbook of methods in cultural anthropology. pp. 259–300. Rowman Littlefield, Walnut Creek (1998)
13. Drettakis, G., Roussou, M., Reche, A., Tsingos, N.: Design and evaluation of a real-world virtual environment for architecture and urban planning. Massachusetts Inst. Technol. Press. 16 (3), (2007)
14. Eran Ben-Joseph, Hiroshi Ishii, John Underkoffler, Ben Piper, & L.: Urban Simulation and the Luminous Planning Table Bridging the Gap between the Digital and the Tangible. J. Plan. Educ. Res. 21 196–203 (2001)

15. Fatah, A., Schieck, G., Penn, A., Mottram, C., Strothmann, A., Ohlenburg, J., Broll, W., Aish, F.: Interactive Space Generation through Play Exploring Form Creation and the Role of Simulation on the Design Table. Int. J. Archit. Comput. 3. (2005)

16. Gaborit, N., Howard, T.: A collaborative virtual environment for public consultation in the urban planning process. In: Proceedings Theory and Practice of Computer Graphics, 2004. pp. 104–111. IEEE (2004)

17. Giordano, Y.: Conduire un projet de recherche. Une perspective qualitative. Post-Print. (2003)

18. Hanzl, M.: Information technology as a tool for public participation in urban planning: a review of experiments and potentials. Des. Stud. 28 (3), 289–307 (2007)

19. Hanzl, M.: Information technology as a tool for public participation in urban planning: a review of experiments and potentials. Des. Stud. (2007)

20. Hevner, A.R., Park, J., Ram, S., March, S.T., Park, J., Ram, S.: Design Science in Information Systems Research. Des. Sci. IS Res. MIS Q. 28 (1), 75–105 (2004)

21. Indraprastha, A., Shinozaki, M.: The Investigation on Using Unity3D Game Engine in Urban Design Study. 3 (1), 1–18 (2009)

22. Jutraž, A., Moine, J. Le: Breaking out: New freedoms in urban (re) design work by adding immersive environments. Int. J. Archit. Comput. 14 (2), 103–118 (2016)

23. Jutraz, A., Zupancic, T.: Virtual worlds as support tools for public engagement in urban design. In: Planning Support Systems and Smart Cities. pp. 391–408. Springer (2015)

24. Jutraz, A., Zupancic, T., Bartolo, C. Di, Veliz, A.: Digital system of tools for public participation and education in urban design: Exploring 3D ICC. Digit. Phys. Proc. 30th eCAADe Conf. 1 (2012)

25. Khan, Z., Ludlow, D., Loibl, W., Soomro, K.: ICT enabled participatory urban planning and policy development. Transform. Gov. People, Process Policy. 8 (2), 205–229 (2014)

26. De Lange, M., De Wall, M.: Owning the city: New media and citizen engagement in urban design. First Monday. 18 (11–4), (2013)

27. Luigi, M., Massimiliano, M., Aniello, P., Gennaro, R., Virginia, P.R.: On the Validity of Immersive Virtual Reality as Tool for Multisensory Evaluation of Urban Spaces. Energy Procedia. 78 471–476 (2015)

28. Maquil, V., Leopold, U., De Sousa, L.M., Schwartz, L., Tobias, E.: Towards a framework for geospatial tangible user interfaces in collaborative urban planning. J. Geogr. Syst. 1–22 (2018)

29. Mueller, J., Lu, H., Chirkin, A., Klein, B., Schmitt, G.: Citizen Design Science: A strategy for crowd-creative urban design. Cities. 72 181–188 (2018)

30. Orlikowski, W.J., Baroudi, J.J.: Studying Information Technology in Organizations: Research Approaches and Assumptions. Inf. Syst. Res. 2 (1), 1–28 (1991)

31. Orlikowski, W.J., Iacono, C.S.: Research Commentary: Desperately Seeking the "IT" in IT Research—A Call to Theorizing the IT Artifact. Inf. Syst. Res. 12 (2), 121–134 (2001)

32. Saad-Sulonen, J.C., Horelli, L.: The value of Community Informatics to participatory urban planning and design: a case-study in Helsinki. J. Community Informatics. 6 (2), (2010)

33. Sanders, E., Stappers, P.: Convivial toolbox. BIS, Amsterdam. (2012)

34. Van Schaik, P.: Using interactive 3-D visualization for public consultation. (2010)

35. Seichter, H.: Augmented Reality and Tangible Interfaces in Collaborative Urban Design. In: Computer-Aided Architectural Design Futures (CAADFutures) 2007. pp. 3–16. Springer Netherlands, Dordrecht (2007)

36. Seichter, H.: Sketchand+ A collaborative augmented reality sketching application. In: Proceedings of the Conference on Computer-Aided Architectural Design Research. pp. 209–219. , Bangkok (2003)

37. Shen, C., Ryall, K., Forlines, C., Esenther, A., Vernier, F., Everitt, K., Wu, M., Wigdor, D., Morris, M.R., Hancock, M., Tse, E.: Informing the Design of Direct-

Touch Tabletops. (2006)

38. Turan, S.Ö., Pulatkan, M., Beyazlı, D., Özen, B.S.: User Evaluation of the Urban Park Design Implementation with Participatory Approach Process. Procedia - Soc. Behav. Sci. 216 306–315 (2016)

39. Voinov, A., Kolagani, N., McCall, M.K., Glynn, P.D., Kragt, M.E., Ostermann, F.O., Pierce, S.A., Ramu, P.: Modelling with stakeholders – Next generation. Environ. Model. Softw. 77 196–220 (2016)

40. Wates, Nick, Brook, Jeremy, De Lange, M., De Waal, M., Salter, J.D., Campbell, C., Journeay, M., Sheppard, S.R.J., Yeang, L.D., others, Jutraz, A., Zupancic, T., Slotterback, C.S., Senbel, M., Church, S.P., Panagopoulos, T., Andrade, R. dos R., Barreira, A.P., Luigi, M., Massimiliano, M., Aniello, P., Gennaro, R., Virginia, P.R., Fonseca, D., Valls, F., Redondo, E., Villagrasa, S., Turan, S.Ö., Pulatkan, M., Beyazlı, D., Özen, B.S., Hanzl, M., Saad-Sulonen, J.C., Horelli, L., Ben-Joseph, E., Ishii, H., Underkoffler, J., Piper, B., Yeung, L., Köninger, A., Bartel, S., Ahn, H.-C., Jacobi, M., Halatsch, J., Kunze, A., Schmitt, G., Turkienicz, B.: The community planning handbook : how people can shape their cities, towns and villages in any part of the world. Springer (2000)

41. Westerberg, P., Von Heland, F.: Using minecraft for youth participation in urban design and governance. (2015)

42. Wu, H., He, Z., Gong, J.: A virtual globe-based 3D visualization and interactive framework for public participation in urban planning processes. Comput. Environ. Urban Syst. 34 (4), 291–298 (2010)

43. Yeang, L.D., others: Urban design compendium. English Partnerships/Housing Corp. London. (2000)

44. Changing places, http://cp.media.mit.edu/cityio/, Accessed: July 01, 2017

45. Everyday Objects as Interface : Collaborative MouseHaus Table , a Physical Interface for Urban Design.