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Unfolding laypersons creativity through Social VR:

A case study

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Involving laypersons in collaborative design projects faces the challenge of having an adapted representational ecosystem. There is a lack of adequate representational tools for multidisciplinary actors to graphically and physically visualize and externalize their ideas. Using VR is a promising way of renewing participatory design, but settings with VR raise the difficulty to express ideas on the model, and to support collaboration since using VR headsets eventually hinder design communication between participants wearing them. In this paper we present the a case study of one workshop involving non-designers as participants, based on collective 3D sketches using a Social VR system (without headsets) which several users simultaneously and immersively sketch using handheld tablets, operating a 3D model as contextual background. The workshop was supported by a representational ecosystem containing: (1) Traditional freehand sketching on paper and working with pre-cut physical components used as boundary objects to represent a scaled model; and (2) immersive 3D model allowing collective life-sized visualization, 3D sketching and interaction.

Keywords: Social VR, Representational ecosystem, Laypersons participation, Co-design

INTRODUCTION

Design projects are complex because they relate to a wide variety of end-users and also involve multiple stakeholders along the process. As users and citizens increasingly demand the right to be fully involved in design projects, we claim new kinds of representations are needed to allow the efficient involvement of users in these projects, in a perspective of active co-design, instead of merely looking for user approval or consensus on previously set design decisions. But involving laypersons in the de-

sign process raises one major challenge: public organizations and design offices dictate the engagement of projects' prime stakeholders by using representations that are not well adapted for this persons, reducing them to the role of receptors instead of actors. Co-design must give the opportunity to all the participants to co-create ideas simultaneously (co-ideation), in a democratic (horizontal) and multidisciplinary way. Nowadays, participatory processes involving laypersons tend to limit their contribution to proposing general, abstract and "immature" design

ideas through ideation techniques like brainstorming or mind maps using post-it notes, without further diving into design concepts at a mature level and resolving them. These techniques succeed in supporting problem analysis, but fail to support the ideation of mature concepts. As designing is a matter of representing (Visser 2006), proper representation tools have to be provided to designers, and especially to laypersons involved in design. Post-it notes and abstract words do not support ideas shaping. Consequently, we claim that the co-design approach needs to be enhanced by an appropriate representational ecosystem supporting active participant intervention. To this end, we developed a Social VR (Virtual Reality) co-design system, to support democratic user participation. Thanks to its natural interaction, immersion and embodiment without wearing VR headsets, users can resolve design problems together with other specialist collaborators, using life-sized representations, immersive and 3D sketches, actively interacting with design ideas. Diverse groups of co-located participants (including architects) are immersed and use different kinds of representations. Because complex codified representations like plans or scaled presentation mock-ups are challenging to grasp for neophytes, we expect Social VR to support representations suited for the creative phases: real-scale, immersive, with high evocative power, and with the easiness of sketch-based graphical expression. The aforementioned representational ecosystem may support user co-creation by immersing them in the project, and facilitating participation. This paper is based on an extensive case study. We first highlight the expected benefits and weaknesses of VR for supporting laypersons co-design. We then present the setting we use to overcome these difficulties, based on a technical solution. Finally, we report and discuss the results of a workshop of the interior design of a library space. The resulting projects were analyzed based on Abstraction Hierarchy (AH) scale showing the coexistence of very concrete and abstract ideas in the co-design process.

USING VR FOR LAYPERSONS IN COLLABORATIVE DESIGN

Using VR with laypersons during a collaborative/participatory urban design process is a promising way of renewing participatory design. VR is supposed to help people to understand spatial properties, to compare designs (Fukuda et al., 2003), to evaluate proposals and to understand context (Kaga et al., 2008). But settings with VR and laypersons raise two major issues: the difficulty to express ideas on the model, and the emergence of barriers in collaboration.

Fukuda et al. (2003) for example used walk-throughs and driver's and bird's-eye view, while reviewing and comparing multiple propositions, including night/daytime designs, making design changes (affine transformations, importing 3D elements, textures and colours) interactively and getting dimensions/quantifying elements. They report that people have better spatial feelings.

Nevertheless, VR was only used for comparison with the present and future conditions, like a physical study model. Moreover, the design proposal was created by a design team and then the other stakeholders studied the proposal, that was modified again only by the designers. Moreover, it seems that in this study only by publicity, the consensus and the trust was build and obtained by citizens. It is important to signify that, citizens never understood master plans data (Fukuda, Kaga & Terashima 2008); (Fukuda et al. 2009).

To ensure citizen participation Kaga et al (2008) added Weblog as middleware of the design tool for information exchange (including texts, pictures, records of meetings and master plan data) combined to VR and Real-time simulations. Based on that, a final solution was prepared. These devices are reported as effective communication tools among stakeholders, supporting efficient and rapid examination and opinion by citizens. But they hardly support real-time, contextualized design information. Moreover, in this setting, it is not clear who participated and where occurred design ideation.

Other options were studied using an economically accessible flow between an easy to learn 3D CAD (SketchUP) system where files were then exported to VR as comprehensive mode of expression for active role of laypersons of reproducing a design context (Fukuda & Takeuchi 2010). Nevertheless, only models of non-specialists were compared to those of VR specialists reproducing the design context. However, the authors do not report any specific design method since they only represented the current space.

Finally, a methodology was implemented to engage laypeople in neighbourhood design (Chowdhury & Schnabel, 2018): One user was designing using a VR headset and a gesture 3D modelling software while other laypersons were observing and designing, by talking to this one. The reported conversation includes design decisions but was tainted by the fact that communication was affected by the blind people person that was using the VR headset. No training about co-design or design process was reported.

In these different settings one can argue that the 3D modelling could hinder abstracts, ambiguous and accurate ideas proposed during the ideation stage. Our approach aims to take advantage of VR for co-design, while enriching the approach by supporting participant contributions (thanks to Social VR) including the use of sketching, developing specific co-design representational ecosystem for laypersons involvement.

REPRESENTATIONAL ECOSYSTEM AND SOCIAL VR

Involving lay persons (untrained in design) in collaborative design projects faces a major practical challenge: having an adapted representational ecosystem. Indeed, non-designers can experience trouble visualizing and placing themselves into design ideas. In particular, the representations that are mobilized by design professionals (scaled models, technical drawings, Computer-Aided Design “CAD” models) do not always make it possible to evoke effectively the characteristics of the project (Van de Vreken

and Safin 2010). In addition, there is a lack of adequate representational tools for inter-professional actors (designers, engineers, users, etc.) to graphically and physically externalize their ideas, that is, to involve positively users in design and ultimately transform non-specialists into real actors. Indeed, non-designers are rarely trained in freehand sketches, perspective views or 3D modelling, tools that are central in “professional” design practice. Externalizing and framing design ideas are also critical for the construction of a common ground in collective processes, which is necessary for the development of quality projects (Stempfe and Badke-Schaub 2002). Kvan (2000) indicates that collaboration is more complicated than the mere participation of a group of individuals. It requires a greater synchronization of work and simply bringing new software and hardware is not sufficient to create the right environment to foster collaboration (Kvan 2000). Thus, communication plays a decisive role for this synchronization which subsequently allows the evolution of each person’s mental representations (Darses 2006).

We have previously studied the characteristics of the representational ecosystem that support or enhance the co-design processes (Dorta et al. 2016a). Four main required elements were found: it has to (1) be hybrid, mixing analog (made by hand) and digital representations; (2) allow project visualization using several scales including life-sized; (3) support active co-design by allowing all users to represent through sketches and physical models and manipulate these representations, all in an intuitive way; and finally, (4) the ecosystem must grant opportunities to use and bridge across several kinds of representations, including physical (models) and graphical (different views, photos, etc.). For this purpose, we developed an immersive co-design platform Hybrid Virtual Environment 3D (Hyve-3D) (Dorta et al. 2016b) (Figure 1), improving local and remote design communication. This system allows local immersive co-ideation while integrating themselves to the representational ecosystem. The system consolidates multiple representations which support co-ideation without inter-



Figure 1
Hyve-3D multi-user
immersive 3D
sketching

fering with the process, in contrast to traditional CAD tools. It permits to work at different scales (including life-sized) with hybrid representations and to co-ideate in an active way via immersive and 3D sketches and interaction using handheld devices. The system supports the communication between local participants and is considered as “Social VR” because they don’t use occlusive headsets that hinder their verbal and non-verbal communication (e.g. design gestures) allowing to share the collective design experience.

Hyve-3D has a three-dimensional representation of a drawing area moving it in the 3D space by combining changes in the orientation of the tablets and 3D tracking them (optical or magnetic) or using multitouch gestures. 3D immersive sketches can be combined with imported 3D geometries from a commercial 3D modeller or photogrammetry files (.obj for-

mat) (Dorta et al. 2016b) (Figure 1). Hyve-3D VR Cinema software also project immersive 4K movies on the screen captured by 360 4K cameras as the Go-Pro Max. The system permits to be interconnected in real-time to other remote systems to allow simultaneous remote co-design.

CO-DESIGNING IN SOCIAL VR: PRINCIPLES

Our setting propose to involve users and stakeholders to plunge in the hearth of design process. This approach is deployed through six-hour (9am to 4pm) workshop, a duration which ensure people participation. During the workshop, laypersons are able to generate mature design proposals in the form of scaled physical models and immersive virtual representations (immersive and 3D sketches on a basic 3D geometry used as context). Designers and ar-

chitects can also get involved in the project as well as engineers, other specialists, and design students as design accompanists (Sanders & Stappers 2008). The workshop is structured in different sessions, each focused on a specific project stage: problem framing, immature ideation, mature ideation and final presentation. During each session, participants alternate between explanations on core concepts (co-design vs. cooperation, basic vs. detailed ideas and the representational ecosystem) and design studio in the representational ecosystem. The goal is to show the rationale underpinning those stages and the developed representations, to favour a better understanding of the process by the participants during the workshop.

The schedule of the day consists of four one-hour sessions, in rooms dedicated to each group (around 6 persons each max.). During each session, the groups are called in turn in the Social VR system around 20-30 minutes to design within the immersive environment. These sessions are interspersed with pauses and theoretical returns on their co-design activities by the facilitators. Each session is focused on a specific aspect of design exchanges: the first session on the problem (re-)definition; the second session on proposing a large set of ideas (immature ideation); the third session on the concept deepening (mature ideation); and the last on the preparation of the final presentation. At the end of the day, formal presentations are held, using physical models and hybrid representations in the Social VR system as support. These presentations lead to the selection of the most collegially promising project among the proposed solutions made by each team. Concerning the representational ecosystem, participants alternate using two kinds of representations.

Traditional graphical and physical representations

They consist mostly in freehand sketching on paper and working with a physical model where all the architectural components (walls, furniture, columns, etc.) are already pre-cut in foam-board or cardboard

at the right scale (depending on the dimension of the given project). The model can be easily assembled and manipulated collaboratively by the participants. This facilitates project discussion and manipulation through their modification as boundary objects (Arias and Fischer 2000).

Social VR system

It allows visualizing the project life-sized and sketching immersively in 3D. The mock-up can be brought inside the system's space. At the end, the physical models and the virtual models on the Social VR system are used to deliberate the best proposition (several if the group of participants is large). The physical and virtual models then also provide final 3D representations of the project used to show to project makers. A short training of one hour about the Hyve-3D interaction is realized the day before the workshop. While an adaption period of few minutes is necessary for some of them, especially during navigation, after the training all the participants report to feel comfortable with the immersion.

CO-DESIGNING IN SOCIAL VR: A CASE STUDY WORKSHOP

In this paper we present one workshop involving non-designers as participants, based on collective 3D sketches using the Hyve-3D, in which several users sketch simultaneously in 3D using as contextual background a 3D model. This project was focused on preliminary phase of the (re)design of the interior of an existing space, a space currently being built, in the context of a university's library in France. Participants were institutions' employees and users (professors and/or students that attend that facility), as well as architecture and design students, which participated as accompanists to facilitate the design process. Among their tasks, the accompanists focused on the proper use of the different kinds of representations, on exploring alternatives to avoid getting stuck with only one idea or on helping in the discussions and the development of design arguments. Two teams of six participants (users and employees of the



Figure 2
Hyve-3D allowing
collective 3D
sketching; and
rough scaled
physical models

library and 1 design accompanists per team) participated in this full-day workshop, divided in four work sessions, each with a duration ranging from 45 to 90 minutes: the first session was focused on analysing the problem, the second on exploring solutions, the third on refining the solutions, and the fourth on finalising the model.

The workshop was supported by a representational ecosystem containing two major settings:

1. Physical mock-up: scale model pieces were pre-cut and used as boundary objects to assemble the physical model while designing the ideas. A “workshop space” allowed participants to craft their own mock-ups elements.
2. Immersive digital model: The Hyve-3D allows collective 3D sketching using two handheld tablets. In that concern, we also provide a basic 3D model as a contextual background, made from SketchUp and textured in a baking process using a rendering software (Figure 2). In two periods of 30 min., four participants were trained to sketching in 3D and to interact with the model (affine transformations + navigation) using the two tablets of the Hyve-3D.

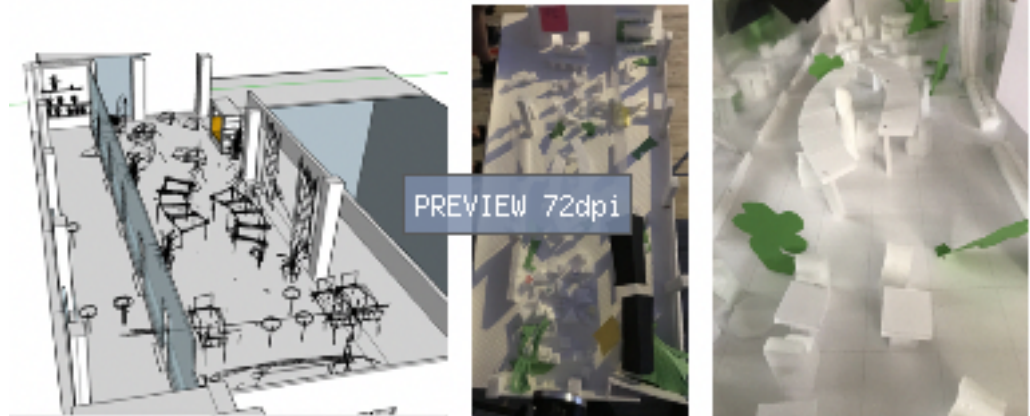
During each work session, each group alternates between these two types of representations. The brief was the re-design of a “coffee shop” space close to the university’s library in a building currently being built.

RESULTS OF THE WORKSHOP

In order to assess the richness of the produced ideas, we classify each produced concept on the abstraction hierarchy (AH) scale described notably in Bizantz and Vicente (1994), which distinguish five different layers in design projects, from the most abstract to the most concrete levels of abstraction: Functional purpose, Abstract function, Generalized function, Physical function and Physical form. Reformulated in the context of our design project, we distinguish the five following levels: (1) general organization of the space, (2) expression of concepts about atmosphere or functions, (3) prefiguration of new services or activities, (4) synthetic concrete proposals, to (5) precise design of furniture elements. The idea is to be allowed to represent all levels of abstraction.

The synthesis of the first group proposal is the following: the space is sub-divided in three areas (general organization) with two key words: fluidity (concept) and flexibility (concept). To manage fluidity, the spaces are not delimited or separated (proposal), but green plants provide markers (proposals), and screens are available if users want to isolate themselves (proposal). The first subspace encompasses a self-managed restaurant (service) around a user-friendly service table (furniture), without proposing distributors, considered cold (concept). There are chairs and tables in classical arrangement (proposal). The second space is composed of curved mobile tables (furniture) and suspended lamps with electrical outlets (furniture). Transpar-

Figure 3
Final model (left),
final mock-up
(center) and zoom
in piece of furniture
(right) for the first
group



ent movable panels (furniture) help to delimit group workspaces and provide boards for group work (service). Billboards are present for ephemeral events (service). The third space is a relaxation space (concept). It consists of flexible furniture, low- and high-height (furniture) that can be used as chairs, tables, armrests, etc. Game boards are printed on these pieces of furniture to invite relaxation and play (service). Lockers are added to allow users to free themselves from their personal belongings (proposal). In the outdoor area, there is a community vegetable garden in self-service (service), and deckchairs and elements for rest and relaxation (proposal) (Figure 3).

The second group designs the cafeteria as a multi-functional space (general organization) with a strong link to the library and its missions (atmosphere). Thus, the corridor adjoining the cafeteria and leading to the library is equipped with a book printer (services), a book exchange area (service) thanks to windows suspended from the railing, allowing books to be seen both from above and from below in the entrance hall of the building (furniture). As one approaches the entrance to the library, showcases (proposals) display the library's collections. A guest book is available to users (proposal). Like the other group, the central space is divided into three functions. A "forum" area allows to hold courses and

mini-conferences, but also to relax informally (service). It is composed of semi-circular furniture and closed by a circular glass (furniture). The central area, dedicated to work, is composed of mobile tables with integrated tablets (furniture), to consult the library's resources (service). Circular mobile panels surrounding the columns (furniture) support visibility of researchers' scientific work: posters, publications (service). The third area, catering, is composed of beverage and food dispensers (proposal), poufs and coffee tables (proposal), as well as a dispenser of small stationery equipment (service). A technical room is converted into a self-service collective kitchen and laundry room (service). The outdoor area includes, like the first group, a self-managed vegetable garden (service) and is equipped with coffee tables with relaxing sofas (proposal), a board game box, a ping pong table, a table football (service). On the columns are integrated storage spaces for ping pong equipment (furniture) (Figure 4).

The projects contain proposals at all levels, moving from very abstract elements (general organization, ambient concepts) to very concrete elements ("immature" proposals but also furniture or decoration elements that are completely designed and "mature"). Users, placed with relevant representational ecosystems are able to produce concepts that are at

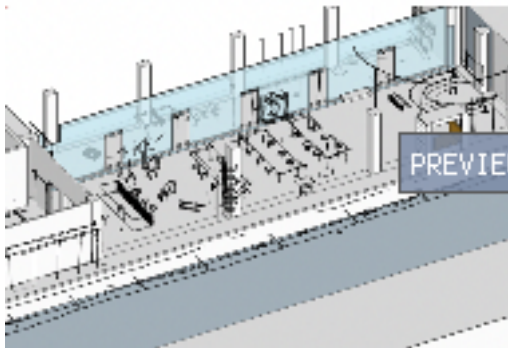


Figure 4
Final model (Left),
and mock-up
(Right) for the
second group

the expected level of precision in a pre-project phase (ideas are instantiated to their concrete form, or even their dimensioning) and, importantly, accepted and internalized by all.

While laypersons' consultations can often be criticized for the fact that emerging proposals are essentially abstract ideas (or floating ideas as in brainstorming sessions), sometimes decontextualized intentions, about a quarter of the proposals in this workshop are of a very low abstraction level, i.e. the concepts are shaped, dimensioned, designed in their formal aspects (type "furniture" in our categorization, and physical form in the AH classification). More than half of the ideas put forward take a concrete form (physical function & physical form) and the other proposals, sometimes expressed in a more abstract form (prefigured services and concepts of use), allow to think of space in its globality. It turns out that the design problem is appropriately broken down, and some elements of the proposals are just drafted, in order to reduce the uncertainty and magnitude of the problem and to allow the group to refine some elements, as professional designers do. The results of the workshop, as well as the process implemented to achieve them, are therefore of a level of quality close to that which can be implemented by professional designers, although it is articulated in a very different way. While lay people have little control over technical constraints (particularly cost and feasi-

bility), which can lead to some unrealistic proposals, the argumentation process of co-design (and notably the proposals justification), makes it possible to get as close as possible to tacit knowledge of the places and to identify the most important needs or desires. Thus, in both groups, we see the emergence of many services, which were not anticipated by the project owner and the project manager, but which are very relevant for users and site managers.

Therefore, we can consider the design process to be complete: propositions range from abstract intentions to concrete designs; and they are based on current situation, as well as projections in future services and opportunities. This completeness has been supported by the representational ecosystem.

The representational ecosystem was an efficient support for the project. Indeed, the two modes of representation are complementary to each other in order to support the expression and materialization of ideas in the project. Depending on the possibilities of expression, one or the other medium is preferred. The group 1's lamps and ceiling lights are designed in the Hyve-3D, supporting the production of complex shapes and the installation of elements in 3rd dimension (ceiling), while the modular furniture with printed foam boards enables the quick arrangement and re-arrangement of many elements (especially furniture), supporting iterations in global space organisation. Moreover, it permits some formal ex-

plorations, by sculpting in the foam new elements to be integrated into the physical model.

DISCUSSION

All groups came to interesting results, even surprising, given the initial objectives, and according to the client and the participants. All participants reported having experienced a rich and interesting day, and having actually contributed to their project. The managers of the library and the building are extremely satisfied with the result, both in terms of the quantity and quality of ideas produced, but also in terms of the process implemented. These informal observations and feedbacks shed light on the relevance of this co-design approach, which is based on the representational ecosystem (Social VR and traditional tools such as pen-and-paper and physical models) to supporting stakeholders' involvement in design projects, as well as to making emerge pertinent ideas for the project.

Another interesting informal observation relates to the relevance of the phenomenon of Social VR for the construction of a shared vision of the project. Indeed, we observed that the different teams right out of Social VR directly address new issues of design, without going through a reformulation of the discussions made in the system. So, it seems that the teams are directly operational for the design starting from Social VR, indicating its capacity to support a truly shared vision of the problem. The Social VR and the physical models have been widely used both by all participants, even those who were not familiar with design (librarians, students, teachers, etc.). These representation modes seem more intuitive than the conventional representation tools like 2D or perspective sketches. The directly perceptible scale (and the complementary scales) that these two modes of representation convey seems to be a determinant of the perceived effectiveness. It appears that both the Social VR system and the physical model were relevant platforms for supporting multidisciplinary collaborative design.

As mentioned, the representational ecosystem

supports different kinds of expression, some pieces of furniture are preferentially designed with one or the other tool. But the two representational tools also allow complementary perception of space to be designed, and complementary design moves: mock-ups afford assembly of elements, spatial arrangement with a global view of the space, and a global understanding of the space, its proportions, its constraints and functionalities. Social VR supports contextual sketching of proposed design elements in space (new furniture, walls, etc.) with a focus on aesthetics and appropriate proportions, and supports an immersive understanding of the space: circulations, ambiance, light, sense of proportions, activities, etc. As we already identified that different types of representations convey different features to understand the projected space (Van de Vreken & Safin, 2010), this study also shows that different representational media supports different spaces of expression and ideas generation. This observation supports the ideas that, especially for laypersons, there is not one best design tool, but rather that the efficiency of co-design lies in the multiplication of tools and representations, i.e. the ecosystem. Each participant may have different preference, cognitive styles, previous experience and degrees of confidence, and providing multiple representational tools may help to provide a full experience where anybody can contribute.

Finally, we made another interesting observation: as the workshop was progressing, we have seen an evolution of the commitment of the participants. While the first sessions were held calmly, with very fluid speech turns, the last sessions were characterized by more assertive behaviours from all the participants: more verbal exchanges, many collective actions on representation tools (mainly physical model) and more engaged postures. Finally, although all stakeholders were very enthusiastic about the process and the project, the impact of this kind of workshop on the design project has not been formally assessed.

Lastly, one of the stakeholders' suggestions, which must be considered in the method we propose, concerns the more recurrent implementation

of this type of workshop, to be able to involve more people and continue to develop and deepen the ideas and concepts proposed.

CONCLUSIONS

This paper presented a setting to involve laypersons in designing based on Social VR combined with physical mock-ups as boundary objects. Feedback from a real co-design workshop involving lay persons as participants was reported. The approach allows during a single day workshop to propose mature designs via 3D representations to engage with real project makers. Of course, the approach described here is based on a case study, and does not allow to draw any definitive conclusions. More extensive studies and more systematic analysis will be done in the future: comparing immersive vs. non-immersive co-design processes, different project layouts, measuring engagement of participants, etc. Even if a specific Social VR devices was used, other VR systems as headsets combined with big projections and immersive walls could be used, of course considering the use of physical components to complete the proposed representational ecosystem. The goal is to consider the use of the appropriate representational ecosystem to improve participations of non-designers in co-design processes. To this this regard, the first results presented here are promising.

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