User Experience in Mobile Virtual Reality: An On-site Experience

Ana Moural[1], Trond Are Øritsland[2]

[1]Norwegian University of Life Sciences, Aas/Norway · ana.moural@nmbu.no
[2]Norwegian University of Science and Technology, Trondheim/Norway

Abstract: Communicating ideas with end-users is one of the main purposes of any design field. When it comes to involving citizens in landscape architecture, lay people struggle reading and interpreting visual elements, e. g. sketches, maps, layout plans, renders. By providing a sense of scale and immersion, virtual reality (VR) might help filling the lack of tools for landscape architects and lay people to communicate at the same level. This paper focuses on experiential and technical issues that may compromise user experience (UX) in mobile VR. In order to assess UX issues, we conducted an on-site study in a square in Oslo. The study involved a group of participants randomly selected at the site. They were exposed to VR panoramas of a hypothetical landscape design developed for that same square. By employing general quality indicators, this paper analyses UX qualities that came out of the on-site experience. Moreover, it discusses the appropriateness of taking mobile VR to the site, and the user experience complications linked to it. The results show that first time users are most likely to be delighted about VR, even though the first experience might be linked to several comfort and interpretability issues. VR appears to be more effective at communicating the design proposal, and providing a better understanding on the relation between real landscape and the hypothetical design.

Keywords: Mobile virtual reality; user experience; on-site experience; landscape architecture

1 Communication in Landscape Architecture and Mobile Virtual Reality

There has been great effort to get landscape architecture more inclusive of those who affect, but also who are affected by landscape changes (COUNCIL OF EUROPE 2000). By gathering different parties, developers and experts are able to consider different feedback and to develop the project accordingly (MOURAL et al. 2018). However, the process of communicating landscape solutions is not always straightforward. Communication between experts and lay people is a well-known issue in landscape architecture. Whereas landscape architects have been trained to communicate through, for instance, sketches, 2D drawings and physical scale models, lay people may not have the required knowledge to apprehend and interpret such elements (AL-KODMANY 1999). Dissemination of information and how to provide a common ground that enables them to communicate at the same level has been topic for discussion and research (GILL & LANGE 2015). However, involving lay people in new ways of thinking and learning might be quite challenging. According to GREENO (1989, p. 135) "cognition – including thinking, knowing and learning – can be considered as a relation involving an agent in a situation, rather than as an activity in an individual's mind".

In this sense, we consider mobile virtual reality (VR) a great opportunity to take design solutions to the site and to disseminate them to the citizens. For the first time since it first appeared in the 60s, VR in now taking advantage of portable widely spread devices, i. e. smartphones. In addition to the smartphone, only a headset is needed to get the users into immersive environments (e. g. Homido Mini VR glasses, View Master Deluxe VR).

Journal of Digital Landscape Architecture, 4-2019, pp. 152-159. © Wichmann Verlag, VDE VERLAG GMBH · Berlin · Offenbach. ISBN 978-3-87907-663-5, ISSN 2367-4253, e-ISSN 2511-624X, doi:10.14627/537663016.

Even considering its eventual hardware limitations – such as graphics and battery autonomy – smartphone-based solutions appear to be the most suitable for on-site experiences, due to its portability and user-friendly interfaces offered by mobile VR applications.

Based on an on-site VR experience, the aim of this paper is to discuss user experience (UX) issues that might be associated with the use of mobile VR as a tool to disseminate information on a hypothetical landscape design in a non-controlled environment.

2 Quality and User Experience in Mobile Virtual Reality

Interpreting visual content in mobile VR poses questions regarding quality of the experience, thus the extent to which the users may consider it 'good' or 'bad'. We chose to sort and analyse the data by using a hierarchy of general quality indicators in VR suggested by CRONIN (2015), inspired by MASLOW's (1943) hierarchy of needs throughout the stages of growth in humans. According to it, *comfort* is the basic in VR. It is the main judgement the user does before deciding on getting engaged with it or not. This aspect is linked to how sensory inputs affect the users' actions and their expectations. *Interpretability* relates to the need of recalling known experiences in order to decide what to do next. As in any other experience in daily life, the users must find indicators that can provide clues about, for instance, where to go and what to do. These are unnoticed aspects taken for granted in daily tasks, but highly needed in a VR environments. Finally, *usefulness* and *delight* are quite close. They are indicators of the value that VR might add to a known situation. For instance, if the user is used to play a game in computer or video game console, when using VR she/he will most likely consider to what extent it adds value to the previous experience.

An experience is "a chunk of time that one went through [...] sights and sounds, feelings and thoughts, motives and actions [...] stored in memory, labelled, relived and communicated to others. An experience is a story, emerging from the dialogue of a person with her/his world through action" (HASSENZAHL 2010, p. 8). The term *user experience* (UX) relates to creating experiences through interactive and physical objects that people can interact with (i. e. devices). Considering VR complexity and how it isolates the user from the physical world, it is of major importance to discuss the aspects involved in a positive VR experience.

2.1 Comfort: Is this Comfortable to Me?

Comfort in VR is about physical aspects that might affect the way users feel while using it. Simulation sickness is the most well-known concerns of comfort in VR. It occurs due to visuo-vestibular conflicts – i. e. the user's visual system says she/he is moving, but his/her vestibular system says she/he is stationary (KEMENY 2014). The symptoms may include nausea, vomiting, salivation, dizziness, headache, eyestrain and fatigue. Issues regarding mismatching movements in reality and VR are also quite common. However, they have not been addressed in the context of this research as it has been limited to VR panoramas[1].

[1] "A 360° panorama is achieved by capturing image information of an entire scene by using images rendered by a modelling software, stitching the images by an image stitching software, and finally playing the 360° panorama on a specific (VR) player" (KONG & LIU 2018)

Visual fatigue is one of the implications caused by depth perception (i. e. perceived distance between the user and the objects in the scene). It occurs when the user tries to focus on objects at different distances in the scene, but it is easier for the eyes to focus the screen distance. The lenses are usually accommodated for the screen depth, not for the scene itself. In order to minimize such discomfort, objects should be placed from 10 meters (static objects) to 20 meters (secondary objects). Distances up to 0,5 meters are not perceived, as the eyes may not be at a straight position (BRENNERS 2016).

Highly detailed and graphically demanding 3D models are more likely to affect the experience, which might lead to technical limitations on position tracking, flickering, low update rates and optical distortion (BEHR et al., 2005). However, compared to desktop VR, mobile solutions minimize such issues by using static panoramas, instead of real-time rendering.

The field of view (FOV) is the extent of the observable world that is seen at any given moment. In VR, it provides references needed for motion, balance and positional awareness, and it provides the sense of immersivness. Wide FOV allows the user to use the peripheral vision to visualize more at once (RAGAN et al. 2015). Binocular human vision allows for 190º horizontal FOV. According to ABRASH (2014) the minimum value for the user to feel immersed in VR is 80º. In spite of the several improvements, FOV in head-mounted display is still far from ideal. Low-end mobile VR solutions (e. g. Google Cardboard and View Master Deluxe) allow for FOV approximately up to 100º, whereas high-end devices (e. g. Oculus Go) allow for 110 º. In spite of the great improvements, VR headsets are far from being able to provide an accurate experience similar to the human eye.

2.2 Interpretability: Does this Make Sense to Me?

Interpretability relates to known experiences assessed by users when deciding what to do next. CRONIN (2015) states that “the environment must be read as natural - not exactly as realistic” so the user can relate to it. According to SHANMUGAM (2015), the following aspects allow for linkage between virtual and physical world: 1) level of detail - close objects should look more realistic and, eventually, allow for interaction; 2) perspective – the user’s perspective over the scene should be approximately the same as the user’s perspective over the real world (the eye height should be adjusted for 1.70m), 3) interface – any virtual environment should be reactive to some extent; 4) manipulation and navigation – user friendly elements should be provided so the user can easily learn how to select, point and navigate.

As quite recent and under development technology, mobile VR applications have not found optimal interaction methods yet. Most of them use specialized control methodologies, which prevent the user from establishing consistent interaction patterns between VR applications. This aspect makes it difficult for the user to get used to each new application.

2.3 Usefulness and Delight: Does this Provide any Additional Value?

As with any technology, VR aims to provide additional value to known situations by enhancing the media content experience. This means that the user must consider how useful and delightful the experience is in order to assess its value. Presence and immersion are key factors in VR, as they allow for new ways of experiencing visual content. Whereas most media vehicles are limited to small-scale elements, VR takes users into immersive environments that are not physically available – immersion and real-scale become its main advantages. The closer to reality the experience gets, the more natural it will be perceived.

3 Method

3.1 The On-site Mobile VR Experience: Participants and Procedure

The study is based on a hypothetical design developed by landscape architecture students at the Norwegian University of Life Sciences. The participants were recruited on-demand at the site. The data collection took place at Schous Plass (Oslo, Norway), on October 28th and November 7th, 2018. The researcher and five assistants were divided into two groups. Each team approached potential participants separately. The teams were composed by one person responsible for introducing the study and conducting the questionnaire, another one providing technical assistance regarding the equipment and a third one observing the experience and taking notes on the users' behaviour and other UX-related aspects (Figure 1). Each participant got the chance to visualize the design solution through three computer generated renderings and three VR panoramas.

The renderings were presented in a regular image viewer application available on the tablet, whereas the VR panoramas (Figure 2) were exposed through Visual Vocal – a smartphone application for VR environments running on a Motorola Moto G4 device and a View Master Deluxe VR headset. By focusing on the teleports – small blue elements visible at the scene – the users were able to navigate from one panorama to another.

Fig. 1: Data collection at Schous Plass

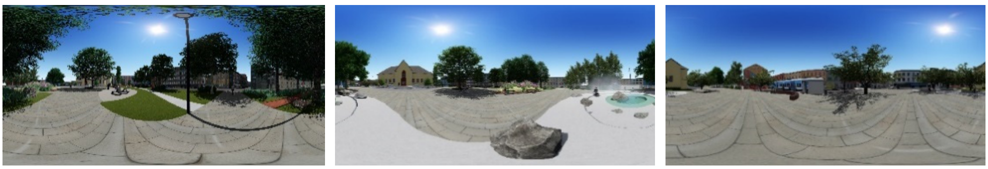

Fig. 2: VR panoramas of the hypothetical design for Schous Plass

This study focuses exclusively on UX in mobile VR, and it does not go into UX issues of using computer generated renderings. The results are exclusively grounded on observing participants while using VR and they are discussed against the hierarchy of needs in VR established by CRONIN (2015).

3.2 Data Analysis

The UX-notes were merged in the same document, grouped according to the following categories and classified as positive or negative: 1) Comfort: signs of dizziness and/nausea, behaviour and/or comment that could be linked to discomfort (e. g. level of detail in the scene, calibration problems, burry image, any physical adjustment to the goggles); 2) Interpretability: navigation and orientation issues; 3) Usefulness: cognitive process and behaviour; 4) Delight: added value of VR.

4 Results

Throughout the experience, we observed multiple comfort issues, whereas others were described by the users. The very first VR experience represents a mix of enthusiasm and discomfort caused by the unpredictability about what is going to happen. This stress condition is visible through limited physical movements and inability to talk while exploring the environment. On the other hand, experienced users feel comfortable and extensively explore the surroundings by looking 360 degrees around and browsing different panoramas.

Visual fatigue is mostly linked to depth perception, blurry images, limited FOV and headset calibration. However, this symptom is highly increased by limited experience with VR. Experienced users get used to it faster and are able to handle such symptoms. In fact, we saw that first time users are more likely to get affected, which lead to dizziness and nausea. Lack of balance occurs once the users face any visuo-vestibular conflict due to the mismatching relation between the physical world and the visual content. Moreover, the users were not fully immersed in VR and they can still perceive the busy city surroundings (e. g. hear people, cars and public transports). Therefore, while in VR, they tend to get stressed about being physically present in the city without any situation awareness.

Interpretability issues occur when the users are unsure about what to do next or even how to behave in VR. Navigation issues are the most common. Whereas some users were not able to navigate from one panorama to another – either because they did not find the teleporters or because they were not able to use them even by following our instructions – others naturally explored the environment on their own. Exploring VR as they would do in reality (by physically walking or even looking closer to the objects in the scene) also suggests that the users are engaged in understanding its limits. Users who felt comfortable doing so also attempted to interpret the VR environment by orientating themselves and relating it to the physical world (e. g. by trying to find their way home). On the other hand, discrepancies between real and virtual worlds (e. g. day light, seasons, weather conditions, vegetation) lea to some doubts regarding realism of the visual content. Once the users get confused about it, it gets more challenging for them to feel immersed.

Very detailed environments do not necessarily mean better experience. Some users got confused about highly detailed scenarios in which their attention gets lost in irrelevant aspects (e. g. the floor tiles were mentioned as “too detailed”, which lead to some degree of discomfort). “Strange” was quite often used to describe the experience. Even though the users were not able to further develop this idea, it might suggest some degree of discomfort.

From the users' perspective, the value brought by mobile VR remains a bit unclear. The human-scale provided by immersive VR allows for better sense of spaciousness, thus better understanding of visual content – an advantage compared to computer generated renderings. However, being able to visualize multiple images at once provides the users with the ability to better relate them and to easily create an impression of the whole environment.

Delightfulness is usually noticed through attitudes and the way users react, use and explore the visual content. The following aspects were linked to some degree of delightfulness regarding the overall experience: easy comparison between reality and VR (by putting the goggles on and taking them off), easy navigation between VR panoramas (by using the teleporters), fully immersive VR environment which could be explored 360º, curiosity about any extra functionalities that could eventually be available.

Some usability issues were noticed throughout the experience. The View Master Delux VR has no straps or similar elements to wear the headset, so the users must hold it with the hands. This limitation does not allow the users to freely use their hands. We noticed some were quite eager to gesticulate while talking about the content, but they felt very limited by holding the headset. Moreover, due to low temperatures, some users chose to hold the goggles with one hand at the time, which caused visible discomfort. The instructions and navigation could have been facilitated if the researcher and the user were both in the VR environment, so the researcher could easily follow the navigation and answer any questions.

When asked about the value of VR, users mentioned the impression of "being there" and "becoming part of the environment". In general, they found it easier to orient themselves in VR, whereas computer generated renderings gave a better overview of the content. Additionally, computer generated images were mentioned as "more relaxing experiences" as users know what to expect and how to use them. Even though it has been mentioned that some elements (e. g. benches and people) are more noticeable in static images, all agreed that VR makes details more visible.

Headache, dizziness and general discomfort were mentioned by several users as discomfort aspects. Blurry panoramas and focus difficulties were also pointed out by some users. Not being able to move around within the scene was also mentioned as a limiting factor, as some users would have appreciated the opportunity to explore it further.

5 Discussion

By taking this experience at the site, we attempted to push the limits of VR further and give the users the opportunity to compare real and virtual worlds. However, we acknowledge that this condition poses additional challenges to the overall experience, which could have been avoided by doing it in a controlled environment.

This is a qualitative study mostly based on observation of the on-site VR experience. We do not base our study in questionnaires, as self-reporting methods may come with some level of unconscious bias. For instance, users may not be able to or they might even feel vulnerable by sharing their experiences (e. g. not being able to use the teleports or feeling dizzy). We acknowledge that the quality indicators (CRONIN 2015) have not been used as tools to measure quality, but rather as guidelines to address subjective aspects on user experience which must considered when developing VR experiences.

Regarding visual content,VR provides an opportunity closer to reality as the user can further explore the environment by looking around at the landscape. On the other hand, computer generated renderings appear to be more predictable in a sense that all information is given at once and the users know exactly how to use them. However, the interface and hardware still have some UX limitations and the users could not get their attention completely away from them. Even though this is more visible for first time users, all encountered interface barriers at some point (e. g. teleportation). Moreover, the hardware might have limited the results. Flickering and blurry images could have been avoided by using different hardware, i. e. smartphones with better resolution and processing power.

After a pilot study, we made adjustments to the 3D model in order to remove the objects placed too close to the user and also those that could have caused visual fatigue (e. g. people who induced movement, even though the scene does not include any moving element; other objects with high level of detail that could catch attention). Even after doing so, the results show that users tend to get distracted by elements that do not belong to the design solution (e. g. people, tram stop and building facades). We noticed they attempt to make a bridge between VR and reality. In fact, they appear to feel more comfortable the more realistic the environment gets. However, they do not necessarily react positively to overdetailed environments.

This study does not aim at using VR for collaborative environments, rather as a tool for individual visualization. Therefore, shared VR environments were deliberately excluded.

Even though mobile solutions open for new possibilities of taking VR out of the conventional environments where it used to belong (e. g. VR labs and other specialized offices), it also limits the experience in a sense that it does not allow the user to navigate through the model. However, this condition represents a huge advantage when it comes to the complexity and computer power required by real time rendering VR solutions.

6 Conclusion and Further Work

With this paper, we aim to contribute with critical thinking on mobile VR to the yet limited research on this recent technology and its application in landscape architecture. By taking mobile VR to a non-controlled environment and testing it on a random sample of participants recruited on-demand, we push user experience in mobile VR further. By doing so, we are able to address UX issues that cannot be considered in any controlled environment. We found the technology suited to communicate landscape design solutions as it clearly eases the cognitive process. It provides sense of human scale, which enables a link between virtual and physical world. In this way, it opens up for unique opportunities to disseminate information and to engage citizens in landscape design discussions. However, the technology has yet a long way to go when it comes to user experience and technical limitations.

For future work, we consider augmented reality (AR) to be worth exploring. AR might facilitate moving around with no need to compute the whole environment while moving. The comparison between VR and AR would give direction for further work on suitable tools for similar on-site experiences.

References

ABRASH, M. (2014), What VR could, should and almost certainly will be within two years. Presented at Steam Dev Days 2014. Seattle, USA. http://media.steampowered.com/apps/steamdevdays/slides/vrshouldbe.pdf.

AL-KODMANY, K. (1999), Using visualization techniques for enhancing public participation in planning and design: process, implementation, and evaluation. Landscape and Urban Planning, 45, 37-45.

BEHR, K. M., NOSPER, A., KLIMMT, C. & HARTMANN, T. (2005), Some Practical Considerations of Ethical Issues in VR Research. Presence, 14 (6), 668-676.

BRENNERS, D. (2016), Interaction design for mobile virtual reality (MIMS Final Project). UC Berkeley, School of Information, California.

COUNCIL OF EUROPE (2000), European Landscape Convention. https://rm.coe.int/16802f80c6.

CRONIN, B. (2015), The hierarchy of needs in virtual reality development. https://medium.com/@beaucronin/the-hierarchy-of-needs-in-virtual-reality-development-4333a4833acc.

GILL, L. & LANGE, E. (2015), Getting virtual 3D landscapes out of the lab. Computers, Environment and Urban Systems, 54, 356-362.

GREENO, J. G. (1989), A perspective on thinking. American Psychologist, 44 (2), 134-141.

HASSENZAHL, M. (2010), Experience Design: Technology for All the Right Reasons. Synthesis Lectures on Human-Centered Informatics, 3 (1).

KEMENY, A. (2014), From driving simulation to virtual reality. Paper presented at the Laval Virtual VRIC'14, Laval, France.

KONG, M. & LIU, Z. (2018), Optical lens accessory for wide-angle photography. United States Patent Publication Application No. 2018/0052308A1. https://patentimages.storage.googleapis.com/a4/5d/2a/9305dba3b1bc98/US20180052308A1.pdf.

MASLOW, A. H. (1943), A theory of human motivation. Psychological Review, 50 (4), 370-396.

MOURAL, A., NORDH, H. & HASSAN, R. (2018), Tools for planning, design and communication in landscape architecture: from conventional approaches to virtual reality. Journal of Digital Landscape Architecture, 3-2018, 163-171.

RAGAN, E. D., BOWMAN, D. A., KOPPER, R., STINSON, C., S., S. & MCMAHAN, R. P. (2015), Effects of Field of View and Visual Complexity on Virtual Reality Training Effectiveness for a Visual Scanning Task. IEEE Transactions on Visualization and Computer Graphics, 21 (7), 794-807.

SHANMUGAM, P. (2015), UX & virtual reality – designing for interfaces without screens. http://www.uxness.in/2015/08/ux-virtual-reality.html.