CO-PRESENCE IN REMOTE VR CO-DESIGN

Using Remote Virtual Collaborative Tool Arkio in Campus Design

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Abstract. A participatory co-design approach is most often counted as a time-consuming method and ends without any concrete solution. Since the new evolution of virtual reality-based communication tools, researchers are trying to integrate citizens in the spatial design making process in-situ situation. However, there has been little research on how remotely co-presence in VR can integrate end-users in a co-design environment in re-envisioning their own using spaces. This study adopts a remote VR collaborative platform Arkio to involve novice designers remotely to design their known urban places. Participants are in three different virtual communication systems. Groups can actively engage in co-creating 3D artefacts relevant to a virtual urban environment and communicate through audio together in a remote setting. The platform was tested with a group of graduate students. The given design task was to re-envision the urban places of their academic institute campus. The sessions have been recorded and transcribed for analysis. The analysis of remote conversations shows that co-presence existed while they were engaged in co-design.

Keywords. Affordable Tools; Remote Collaboration; Smart City; Participatory Design; SDG 11.

1. Introduction

UN-Habitat's people-centred smart city agendas focus on leveraging technological services for the common good by delivering inclusive and equitable participation of local communities in the design decision-making process (Royall, 2022). As a result, many cities have become testbeds for new, untested and sometimes unregulated technologies, forcing local authorities to respond to these disruptive technologies. The trend became urgent as soon as COVID-19 hit the universe. A fast reformation of urban regeneration has been needed to re-envision our urban neighbourhood. Innovation in the integration of disrupted visual communitive tools and design processes leverage the local to re-envision their own neighbourhood by themselves. Such inclusion of the end-users in the design process brings users perspectives which are essential to finding relevant, meaningful and sustainable design solutions. Any participatory design

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solution develops through a meaningful conversation of participants. The process gets influenced by the engagement tools, which traditionally are physical artefacts, drawings and rendering images produced via any digital method. In participatory urban design, people (Chowdhury, 2020) use tools like Virtual Reality (VR) to visualise and construct the design contents in the virtual world, which is more like reality. The three-dimensional (3D) environment offered in the VR conveys and contains information in ways that are not possible using analogue techniques. The tool allows the participants to construct instant 3D artefacts as design inputs relevant to the virtual urban environment (Chowdhury & Schnabel, 2020). However, there is hardly any research where all participants share the sense of co-presence in the virtual environment and actively generate 3D artefacts and collaborate inside the virtual urban space. Traditionally, most urban design community engagement uses VR applications as tools for consultations. They allow the public to walk through the virtual environments and experience the proposed design scenarios but do not collaboratively co-create content in the virtual environment. As opposed to that, UN-Habitat runs a game based participatory design intervention for the marginalised community using 'Minecraft'. The virtual artefacts offered in the participation process is abstract, non-immersive and missing the aspect of participating as individual designers to produce design instantly together at the same time and in the same virtual space. Due to the lack of enough perceptual relevant information of the virtual spaces, the tool struggles to construct relevant imagination in the immersive environment. Compared to that, this research looks at how both remote VR and urban co-design can be done together in the virtual space. The participants can act as a design unit and contribute to conclusive design outcomes. The study employed a VR tool, "Arkio", involving remote participants more effectively via audio chat and experiencing instantaneous generation of 3D artefacts. Together, the representation of the virtual contents in the tool, its capability to produce instant 3D artefacts with design actions and audio conversations engage the users in constructing meaningful urban design ideas.

2. Virtual Co-Presence

In general, the term presence (also known as physical presence) mainly refers to individuals' sense of being' in a virtual environment (Sheridan, 1992). According to Slater (1999), there are three aspects of presence: the sense of 'being there', an individual's response to what is 'there' as real, and an individual's memory of the environment as a 'place' similar to real situation. In the immersive virtual environment, the sense of presence is affected by the vivid, matching and inclusive surroundings in the computer display (Slater, Usoh, & Chrysanthou, 1995). Witmer and Singer (1998) define presence as a subjective experience that depends on the ability to focus on certain stimuli in a virtual environment and exclude the unrelated stimuli of real life. The focused and attentive attributes of the environment involve an individual psychologically and attaches to the stimuli and experiences and allow them to interact with the virtual content. The degree of involvement and immersion in the virtual environment depends on the degree of sense of presence.

The sense of being together is developed through a focused "psychological connection of minds" (Nowak, 2001), which researchers conceptualised as co-presence. The definition of co-presence is the sense of being in the same virtual place

with some sensory properties of place presence and having a mutual awareness of the individuals in the virtual environment (Bulu, 2012). It consists of a sense of feeling that others are actively perceiving us and being part of the group. It mainly addresses the phsychological interaction of the individuals.

Designing a place in virtual environments should be rich enough to activate all the human perception, cognition, and emotion components. The effective engagement with the virtual content depends on the physical properties of the display, objects, actors and the flow of events as design actions. They are responsible for keeping the user interested and involved in the design process. All of them together impact the sense of presence in the virtual environment. In shared virtual environments, the participants are involved in co-presence situations to collaborate actively in design activities. This study reflects on the concept and characteristics of co-presence between immersive and non-immersive virtual environments. The employed system provides distributed designers with a more effective design environment with the sense of "being there" and "being together".

3. Immersive Design Collaboration and Arkio

Co-design or collaborative design is a term to define a process of designing where different parties like designers, architects, engineers and sometimes clients work together to achieve a shared design goal (Gül, 2020). They work together on a design artefact or parts of it. Co-design process is similar to an individual's mental process, which establishes shared goals and develops a shared understanding of design brief, design constraints, framing and examining design problems, and the materialisation of a design solution. In a virtual co-design situation, designers are co-located in the same virtual environment allow verbal and visual communication between parties. The effectiveness of visual communication depends on shared representations of the virtual contents and the types of experiential media, either immersive or non-immersive. In the process, external representation of the virtual environment plays a significant role to interact with the 3D artefacts. The external representation brings the relevancy of the virtual artefacts to the real world. When design thoughts are externalised through artefacts, each artefact contains properties for future interpretations that designers can negotiate during further design development. The representation of artefacts develops conversation both with oneself and with others. These external representations also become the ground for conflicts and collaboration.

Intuitive design collaboration depends on the scope of the artefacts offered by the virtual tools. In participatory design, the role of the tools plays a major part in engaging with the cognitive level of the design decision-making system. Participants decide through verbal communication and responses on the artefacts with design actions. The participants construct the virtual artefacts' representational meaning in the process by relating the visualised information with the actual context. The continuity of design conversation depends on the instantaneous creative responses to the 3D artefacts. Every design action builds a new organisational representation of the artefacts, creating new thoughts for design conversation. The quality of tools' response against design actions is mainly responsible for the quality of the design conversation. This instrumental quality depends on the perceptual affordance of the tool, which Gaver (1991) coined for computer-aided interfaces.

An immersive co-design environment supports an active and real-time experience with the design, therefore presenting a sense of being in the environment. The immersive environment carries a less cognitive load to the participant. In one of the earlier research on remote design collaboration with architectural students, Schnabel (2011), employed communication happened via text and 3D models. In that research, creating 3D artefacts required additional steps, which broke the continuity of design conversations between remote participants and due to that the communication wouldn't happen in a co-present environment. In contrast, in Arkio's virtual environment, users usually experience the higher level of immersion by its extension to the Head Mounted Display (HMD) option. A remote participant can immerse in the virtual environment and locate where the other fellow participants are standing (Arkio, 2021). The interface allows the participants to navigate in the virtual space themselves freely. They can have some self-directed and interactive experiences. Participants can see each other's design actions in the VE and continue conversations. The users feel a sense of co-presence. The tool also offers several default 3D artefacts to place and create new content in the environment. The instantaneous quality of generating 3D artefacts allow the immersive participants to engage in virtual collaboration with the design contents. In this study, the student participants utilise Arkio in a multimodal communication system, where the sense of co-presence is a bit compromised from immersive to non-immersive. One participant was in an immersive environment, and the other two participants were in a non-immersive environment.

4. Research Methodology

The research methodology starts with developing the low-mesh 3D model of the investigation and uploading them in the Arkio (figure 1). The remote collaborators invite the other participants in the Virtual Environment (VE). From the first-person point of view, the remote participants are shown as avatars who talk and take operational design decisions by placing and adding design artefacts in the VE. The

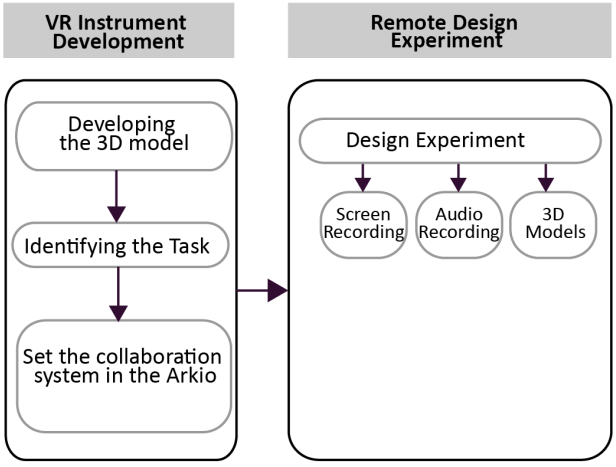

Figure 1. Research framework

design task is given to re-design the landscape of the campus area. The participants can comment on other participants actions and take active efforts in the VE by repositioning the placed artefacts or adding new artefacts. The engagement sessions are recorded, and back-ended data has been saved to report the types of design conversations in the VE.

5. Design Unit

An experimental setup has been developed to leverage designers to participate together in VR urban design. Designer A sees the VE immersed through a Head-Mounted Display (HMD), and as a first-person point of view, he interacts with the 3D artefacts via a controlling device to generate, delete and alter the design. Designers B and C see the 3D artefacts through 15-inch laptop display screens. They together act as a design unit. They interact with the artefacts by instructing others through verbal chat and executing their design ideas by themselves. Figure 2 shows a diagram of a design unit. The diagram is triadic as they are closely related entities and depend on each other actions. Designers generate design action and seek verbal feedback from other co-designers. The process follows a sequence of actions among Designers through the representation of 3D artefacts in the display screen. Designer A is immersed in VE, and Designers B and C are partially immersed through the laptop screens, as screen-based immersed. They together discuss and locate representational 3D artefacts like trees, humans, seatings, vehicles and building forms in the VE. An individual designer generates 3D artefacts as a representation of landscape elements as input in VE, and the output from VE goes to other designers. The communication process let the designers design together as a team rather than acting as individual actors. The collected data from the design experiments reflect on design collaboration.

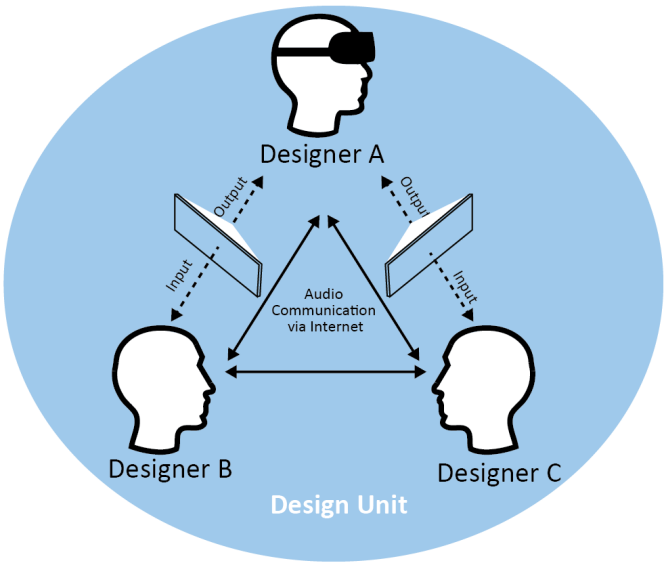

Figure 2. Design unit.

6. Design Task and Participation

The design task is to re-envision the urban settings of the Southern Institute of Technology's campus area. A three-dimensional model of the campus has been provided in the online environment. In the beginning, the designers had been introduced with Arkio for 15 minutes on the basic commands of creating and navigating objects. Then they were allowed to take participate in the design collaboration session for 20 mins (figure 3). The design sessions have been recorded to do transcription analysis.

Figure 3. Participants in remote design collaboration.

7. Transcription Analysis

The research gets the influence from the protocol analysis technique developed by (Chowdhury, 2020; Chowdhury & Schnabel, 2019). The video recorded during the design session has been analysed using "descript", an online tool to transcribe any recorded video (Descript, 2021). A general observation on the trans-coded data, it seems the design discussion went quite well among the participants. Though, in the beginning, the immersive Designer A struggled to orient with the immersive interface. However, Designer B and Designer C were actively engaged in conversation between themselves and progressed with the design. The designers mostly used the 3D artefacts provided by the Arkio interfaces. They placed trees, humans, cars and chairs. They

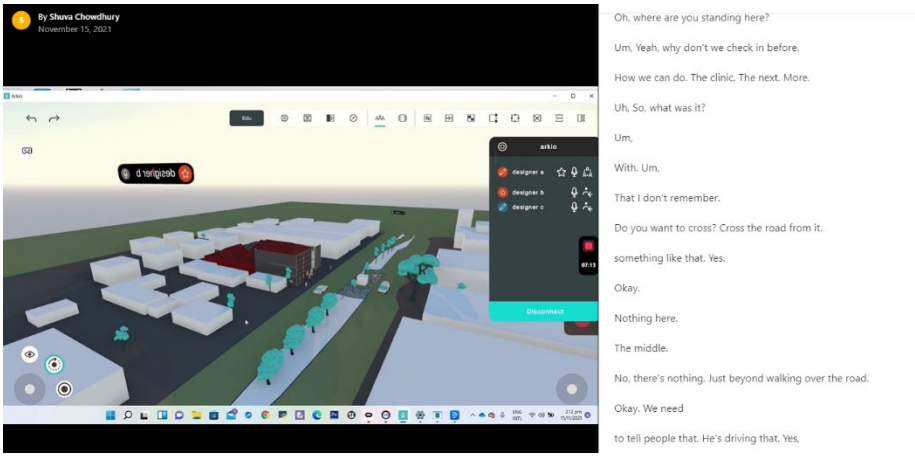

Figure 4. Design negotiation.

planted new trees in the road divider of their campus. In the stage of the design, the students started to propose a pedestrian bridge to connect the building blocks of the both sides of the road. Like one of the conversations regarding that design initiation, *"Do you want to cross? Cross the road from it"* (figure 4). Due to the nature of being co-presence in the virtual environment, students can locate any specific place of the virtual city.

At some stage, the conversation went to the level of negotiation. Like in one conversation, one of the participants said, *"You said it's a bad idea. And I think it's a good idea to have like a. Something that people can walk over…"* (figure 5). Such conversation indicates the quality of the engagement. They consulted between them before producing any content in the virtual place. They sought fellow co-designers choices and, in cases, also instructed each other's to place any specific 3D artefact (figure 6). The quality of the perceptual environment allowed the designers to perceive the scale relevant to their design environment. Like in one conversation, a participant stated, *"Because at the moment. Bridge. Obviously, like it would be quite steep, kind of straight. It down to try and get into G-Block"* (figure 6). There were quite a lot of affirmative and exclamatory word exchanges between the designers, like *"yeah"* and *"Oh"* (figure 5, 6 and 7). The affirmative conversation indicates that the designers are experiencing the same design contents in the VE and the exclamatory words indicate the conversation's natural flow. The designers felt the experience of "sense of being there" and interacted on the same design issue as they were co-present at the same virtual location. The continuation of the design conversation went well. In the end, they started to build a pedestrian cross-over bridge in their virtual campus site. The video transcription revealed that the Designers got the chance to jump on the bridge and visualise the surroundings in different locations in the virtual city.

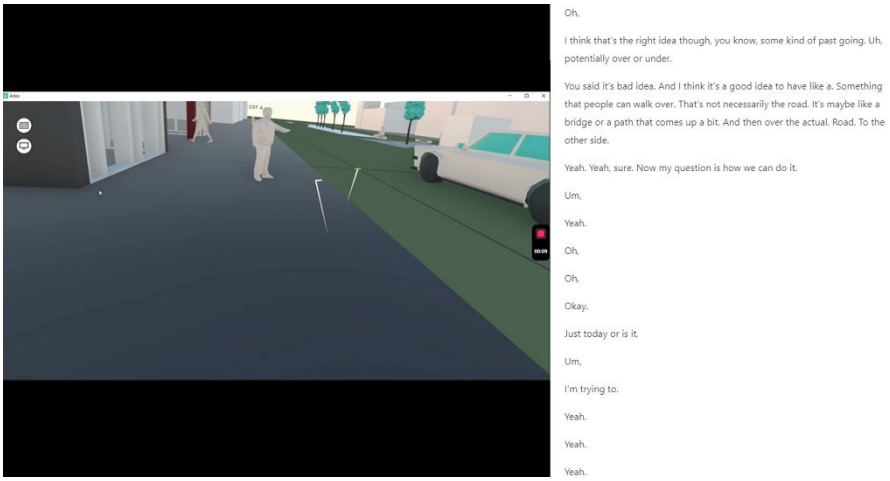

Figure 5. Design conversation in Arkio.

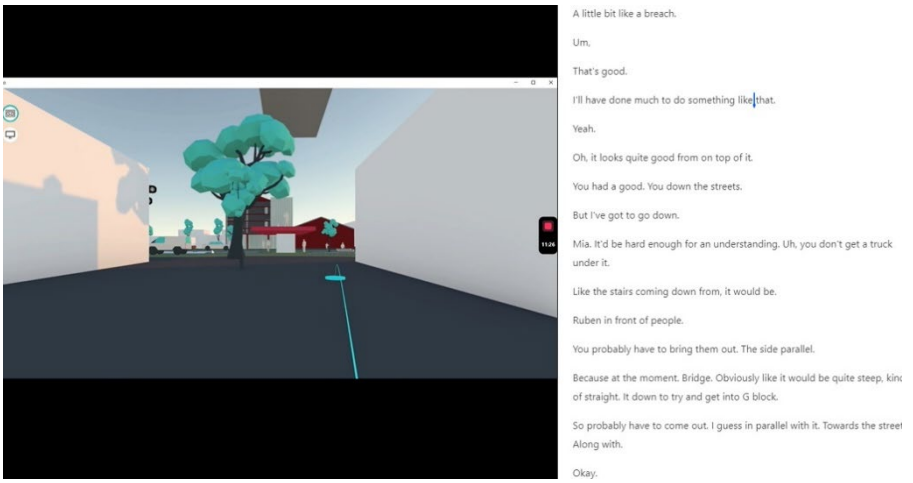

Figure 6. Design instruction.

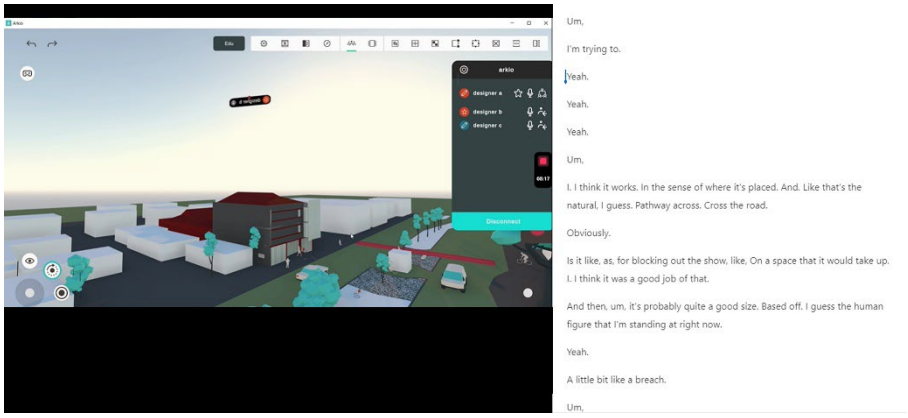

Figure 7. Affirmative and exclamatory conversation.

8. Discussion and Conclusion

In the study, the seamless interaction with the participants reflects the level of presence in the virtual environment. The success of design communication lies in the tool's ability to facilitate the sense of the co-presence of all the remote participants. The participants had enough freedom to input their design aspirations and negotiated with the remote participants to form a collective decision. The VR stimuli involve participants senses and are produced in real-time by their actions. The full immersive Designer A communicates successfully with the non-immersive Designers B and C. The compromisation on the immersion does not affect the conversation. Through the video transcription, it has been identified that the immersive Designer A struggled to orient himself in the VE. It is due to the new orientation of the HMD and the perceptual quality of the surrounding environment. Besides, the user interface was also new to

him. However, Designers B and C interacted in the virtual space without technical barriers.

The study shows that the visualisation process carries genuine and powerful potential to act as innovative and creative communication tools and that communication can go in all directions. The novice designers have undertaken the development and rolling out of methods of 3D modelling and visualisation. The outputs seamlessly incorporate with a formal planning and design process.

Under the framework of participatory urban design, this employed engagement setup can potentially engage the non-expert participants in remote VR collaborative settings. Research on VR-assisted participatory urban design (Chowdhury, 2020) developed a setup where the co-designers experience the immersive designer's design input in screen-based media. The co-designers were not allowed to generate virtual artefacts during the design participation sessions actively. In this study, the proposed design unit configuration allows all participants to contribute to design decisions by actively producing virtual artefacts in the VE. They act as a design team though they are located remotely.

In future, the research intends to explore with the local non-experts community by ensuring equal opportunity and reducing inequalities between policymakers and general citizens. Such wider community participation provides transparency in the decision-making process. Besides, such remote collaboration also shows the scope of exchange knowledge from stakeholders based on different continents. The framework can be a part of the UN's city resilience profiling tool. UN habitat's holistic approach to increasing resilience requires engagement with local government stakeholders and identifying the risk factors that could be prioritised to mitigate. The bottom-up design solution can be found through collaboration and participation in decision-making. In that sense, this kind of remote co-presence virtual co-design tool can facilitate them to identify the priority on spatial planning by visualising possible optimised and sustainable design solutions.

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