Can Collaboration in Multiuser Immersive Virtual Reality Streamline the Design Process?

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Abstract: Multiuser Immersive Virtual Reality (MIVR) tools democratize the design process by enabling equitable contributions from designers and non-designers. This fosters enhanced interdisciplinary cooperation and broadens participation, reflecting evolving and more inclusive landscape architectural practices. Our research focused on collaborative designers' and non-designers' interaction in MIVR during the design process, from initial site analysis and conceptualization until the final proposal presentation. We gathered participants' insights during the three-month experiment, which mimicked a real design process. The results show that MIVR holds significant promise for enhancing collaboration and efficiency in the landscape architecture design process.

Keywords: MIVR, co-design, co-creation, ARKIO, landscape design

1 Introduction

Collaboration is knowledge creation and integration, a joint effort towards a common goal. As defined by ANDREASEN et al. (2015), it is "an *act of mutual motivation and joint process (…) through which actors from different disciplines share their knowledge about the design process and the design itself."* Communication leads to a shared understanding of design content and the design process itself and helps integrate stakeholders' knowledge to define common objectives (ANDREASEN et al. 2015). PERRY & SANDERSON (1998) highlighted that face-to-face communication is the most effective form of communication during a collaborative process. Visual content, which is key to design, might facilitate coordination or foster collaborative project conflicts (HENDERSON 1998).

The interdisciplinary and collaborative approach helps address complex environmental and urban challenges in landscape architecture by combining diverse expertise (BEHZADFAR et al. 2010). Collaboration encompasses various forms of joint efforts, including co-creation and co-design (CONTRERAS-ESPINOSA et al. 2022). Co-creation and co-design during the conceptual phase benefit from integrating multidisciplinary perspectives and stakeholder engagement while engaging community members and other stakeholders in the schematic design phase helps ensure that the design meets the needs and preferences of all involved parties (ROVIRA 2016).

Digital tools and online platforms for remote collaboration have introduced new dynamics to participatory design processes, allowing for continued community engagement despite physical distances (REITH et al. 2021). Immersive Virtual Reality (IVR) is a computer-generated simulation of a three-dimensional environment that can be interacted with using special equipment such as a head-mounted display (HMD), controllers, or gloves. IVR aims to create a realistic, immersive experience, and hand and body tracking allows users to interact with objects and characters in the simulated environment. It is characterized by five "i"s: "intensive, interactive, immersive, illustrative, and intuitive" (SHERMAN & JUDKINS 1992). Multiuser IVR (MIVR) enables designers and stakeholders to interact with three-dimensional

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space and improves spatial understanding and decision-making (HILL et al. 2019). It allows different participants to experience virtual space simultaneously through their avatars (LEE et al. 2023), which enhances the sense of presence and co-presence, leading to more effective collaboration (KEUNG et al. 2021). MIVR facilitates real-time interaction and communication among geographically dispersed participants, which might be particularly beneficial during design review meetings and virtual face-to-face discussions (TEA et al. 2022, AZIZO et al. 2022, TRAN et al. 2023). The intuitive character of MIVR allows even non-experts to rapidly prototype their concepts (GEORGE et al. 2017), making it a powerful tool for understanding design ideas, improving efficiency, and ensuring the quality of the proposed solutions (LIU & WANG 2019). Studies have shown that using MIVR applications can lead to better identification of design errors compared to traditional methods, as users can immerse themselves in the virtual environment and conduct thorough inspections (TEA et al. 2022, TRAN et al. 2023, JOHANSSON & ROUPÉ 2024)

MIVR can be used during different phases of the design process. Nowadays, it is primarily used for design review in the later stages. However, its application in earlier stages, such as analysis and concept development, can also be beneficial (GEORGE et al. 2017, HILL et al. 2019). MIVR environments enhance user engagement and motivation, making collaborative tasks more enjoyable and productive. Avatars and shared objects in the virtual space encourage creative solutions and unexpected outcomes, which benefit the design process. (FENG et al. 2024)

Combining MIVR with traditional landscape architecture methods requires careful planning to maximize its benefits. Despite the advantages, technical challenges such as rendering performance, data compatibility, interoperability issues, participants' learning curves, and the need for specialized equipment can limit accessibility and collaboration across different platforms (JOHANSSON & ROUPÉ 2024).

Our study aimed to analyze the effectiveness of streamlining the collaborative design process in landscape architecture using MIVR. The objective was to observe and interpret interaction patterns during different phases, from the initial site discovery through concept development to schematic design refinement and presentation.

2 Materials and Methods

Our experiment lasted three months, during which participants from different backgrounds worked on developing a proposal for a real site in Batroun, Lebanon, which they visited at the beginning of the process. The sample size was limited by the equipment available and involved 11 student participants who enrolled voluntarily in a course entitled "Special Topics in Landscape Architecture" offered at the American University of Beirut. The participants had diverse academic backgrounds: design disciplines (6 – landscape architecture, architecture) and non-design-oriented students (5 – engineering, biology). All participants were informed of the study's objectives and participant expectations. Given its exploratory and experiential character, they confirmed their willingness to share insights on the process and their readiness to engage in post-experiment focus group discussion. The pool of participants was deemed sufficient for qualitative analysis, allowing for in-depth observation of MIVR's impact on the collaborative design process while enabling data collection and analysis manageability. Participants worked in four mixed groups (of designers and those without design backgrounds). They were tasked to create an urban design project, including a streetscape and two plazas, focusing on spatial relationships rather than realistic landscape graphics, such as tree foliage. We used OCULUS2 headsets, and the equipment was available throughout the experiment without any time limitation. Since the design process within landscape architecture unfolds over different stages, from initial concept generation to final design presentation, this study grafted MIVR integration within these various steps to offer a better understanding of its role, starting with understanding the tool and finalizing with the presentation of the outcomes.

Tool Discovery: In the initial phase, participants were introduced to headsets and several MIVR software: ARKIO (www.arkio.is), GravitySketch (gravitysketch.com), and ShapesXR (www.shapesxr.com). They all include an intuitive environment for collaborative design, spatial creation, and prototyping. This array of tools was selected based on the availability of free or educational licenses and the ability to host multiple users simultaneously. Following an exploration period, participants decided to use ARKIO because they felt more comfortable using its interface and library features. This decision was also influenced by ARKIO's capacity to import and export models from standard Architecture, Engineering, and Construction (AEC) Industry tools (CAD, Revit, Rhino).

Site Exploration: Participants visited the Batroun site in person early in the course to document spatial and contextual aspects. Complementary techniques to MIVR, such as 3D reconstitutions obtained from photogrammetry, were used to enhance spatial awareness and understanding of site-specific dynamics. In particular, participants captured building facades, terrain elevation, and street details, then imported simplified 3D meshes into ARKIO to inform the upcoming design. This enabled an intuitive understanding of spatial relationships and scale, assisting in identifying key site features, topographical nuances, challenges, and opportunities beyond traditional analysis methods.

Ideation and Refinement: During ideation and design refinement, this study relied on a build-and-test methodology similar to that used in virtual prototyping research. The process was iterative, where participants used MIVR to build design ideas and add details on the go, mirroring real-world design complexities. This phase relied on fostering a dynamic, collaborative environment to rapidly prototype, evaluate, and amend the models in the responsive co-design process, with cycles of conceptualization, testing, and feedback. This was possible thanks to instant visualization of design decisions, and every iteration allowed for amendments or layer addition (i. e., materiality, etc.). Finally, participants presented their projects to the invited professionals, who could interact in MIVR and discuss the outcomes with the teams.

Qualitative Assessment: A combination of qualitative methods was employed to document participants' experiences and assess the effectiveness of MIVR. Participants were asked to share regular posts in a private Facebook group, including screenshots and videos accompanied by reflections on their ongoing activities. At the end of each milestone, participants submitted written reports comprising observations on collaborative dynamics and detailed technical challenges, such as file import or texturing issues. Following the final presentation, a 60-minute focus group discussion was organized, recorded, transcribed, and analyzed for participants' statements related to 1 – collaboration and teamwork, 2 – engagement and interaction, and 3 – navigation and adaptability.

A thematic analysis approach was applied by triangulating data from the focus group transcript, Facebook reflections, and milestone reports. This analysis focused on identifying recurring themes and patterns in participants' experiences, such as the perceived ease of use, the effectiveness of collaboration, and the ability to adapt designs within the MIVR environment. Two researchers independently triangulated collected data to reinforce the reliability of the analysis and strengthen the credibility of the findings.

3 Results

We analyzed the three themes by triangulating participants' statements and identified nine recurrent subthemes. The Facebook posts brought the least value out of the three analyzed data sources because participants mainly shared screen captures of their progress with short captions. The focus group discussion brought the most overall value, while the reports gave more insights into the process. Both researchers had similar outcomes regarding subthemes identification, and slight discrepancies were discussed[1].

3.1 Collaboration and Teamwork

- Real-time Synergies – MIVR enables immediate collaboration by allowing multiple users to co-edit and visualize the same 3D model simultaneously, accelerating group decision-making. *R* ”(...) *When it was decision-making time, we all entered VR and would toy around with the issue at hand to take a decision”*
- Role Distribution – Non-designers and designers adopt flexible roles in MIVR, with non-experts gaining confidence in conceptual tasks while designers often rely on tools they know – *R* ”(...) *Non-designers expressed that they had a chance to participate in site inventory and analysis for the first time… it gave them a new understanding of the site's assets and constraints”.*
- Technical Friction – Connection issues, lag, and version-control mismatches can disrupt the collaborative flow, temporarily undermining MIVR's potential for streamlined design. *F* ”(...) *Opening a meeting needs a strong internet connection, we got disconnected many times and this affected our performance.”*

All participants agreed that the overall designer/non-designer teamwork was effective and collaborative, generated new ideas, and all perspectives were considered. "*(Meetings) were very helpful while working as a group where we were able to share input instantly and design together while discussing opinions and perspectives.*" Although non-designers hesitated initially about their role in the process, they caught up quickly and actively contributed to the participatory decision-making. Designers highlighted that working extensively on model creation allowed them to notice several details (for example, architectural details of the buildings) that they usually would not pay attention to. Building the model gave participants a new perspective since they could observe the site from different viewpoints in MIVR, not only at the human eye level. Non-designers expressed that they had a chance to participate in the site inventory and analysis for the first time in their lives, and it gave them a new understanding of the site's assets and constraints. Participants reported that iterating on the design in response to feedback and testing led to a more refined final product.

[1] The sample quotations from the participants' statements are written in the original form; therefore, they might contain typos, abbreviations, and errors. Each sample quotation source is identified with a code – FG – focus group, R – report, F – Facebook.

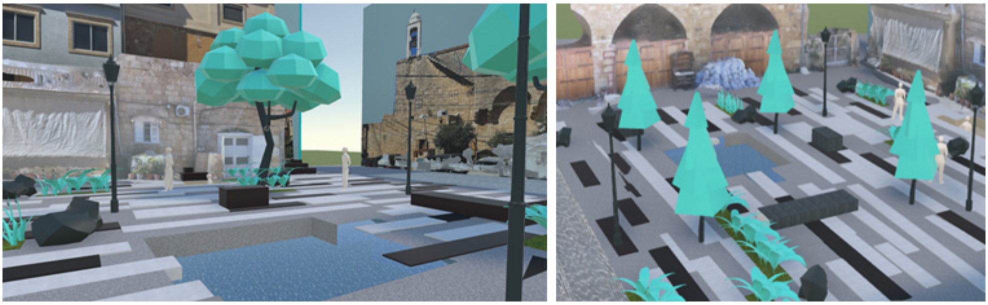

Fig. 1: Participants prototyping different spatial configurations and vegetation types

3.2 Engagement and Interaction

- Immersive Environment as a Drive – MIVR can stimulate creativity and motivation, making design exploration more engaging and intuitive. *FG* ”(...)*Using the Oculus became much easier with time. Ability to elevate/teleport/change views became very natural and intuitive just like playing a video.”*
- Gamification and Social Presence – Playful interactions replicate an in-person feel, breaking down communication barriers and fostering a more relaxed, experimental mindset. – *FG* ”(...)*We had a fist fight in VR. Each one of us could be in a different part of the room, but it feels like we're next to each other, we're talking to each other like we're face to face.”*
- Technical Friction – Glitches, motion sickness, and other hardware limitations occasionally interrupt immersion, diminishing the otherwise heightened engagement offered by MIVR – *FG* ”(...)*I got dizzy when I was trying to fly around. And it glitched, from my side it glitched a lot and it was out of control.”*

The exploratory phase (Fig. 2), during which the participants discovered the tool and tested different software, was reported as *“fun”* and *“playful.”* As per the participant's observation, “*Customizing the avatars was a playful experience that allowed participants to create their own virtual identities.*” This informal, enjoyable atmosphere reduced inhibitions among participants, fostering a creative environment.

3.3 Navigation and Adaptability

- Intuitive Navigation in MIVR – Basic actions feel natural in VR, reducing barriers for newcomers and supporting rapid spatial exploration. – *FG ”(...)It's just like playing games, the screen is all over you, I liked it.”*
- Early Detection of Design Issues – Viewing models at a 1:1 scale in VR uncovers misalignments or sizing errors earlier, minimizing revisions downstream. – *FG ”(...)We realized the ramp was too steep the moment we walked on it in VR.”*.
- Balancing VR and Desktop for Details and Precision – Many participants switched to traditional CAD software for refined geometry and precision tasks. – *R ”(...)We had to tear up the older model… This time, we assigned real-life measurements in a partial model, then used the PC for precision editing.”*

Fig. 2: Participants presenting the projects simultaneously in MIVR and on a laptop

During the inventory and analysis phases, participants reported several technical issues in creating effective models, such as difficulty incorporating model materials in ARKIO. "*I wish objects could just be imported with their texture and able to edit them later because importing texture alone and applying is timely and tricky.*" The participants found the MIVR very intuitive and easy to use; however, during the conceptualization phase, designers preferred to use their laptops, which made the process less interactive. Designers worked on the software they knew previously, such as AutoCAD, SketchUp, or Lumion, and exported the proposal to ARKIO for purely visualization and assessment purposes. Surprisingly, non-designers were much more flexible and felt comfortable in MIVR during the conceptualization. They highlighted that designers used software they did not know, which weakened their collaboration level in formulating the idea. At a certain point, they felt excluded from the idea generation. Nevertheless, the participants found a way to work collaboratively: "*We tried acting in VR and one (designer) on PC to test different perspectives. When it was time for decision-making, we all entered and discussed our POVs to finalize the design.*"

4 Discussion

More than 30 years ago, SHERMAN & JUDKIN (1992) described the characteristics of virtual reality as five "i"s; with dynamic equipment and software development, their definition can be expanded further with five "c"s—conceptualization, collaboration, communication, co-design, and co-creation. PERRY & SANDERSON (1998) statements on challenges for the collaborative process when the team is geographically distributed are not valid for MIVR – the virtual space became a space of collaboration, discussions, and actions. REITH et al. (2021) claimed that the whole engagement in virtual/online space is unrealistic personal and physical connections of participatory methods. Our research proves that using avatars enhances the experience of face-to-face presence/co-presence in the virtual environment, as stated by LEE et al. (2023) and KEUNG et al. (2021). Customizing the avatars was a playful experience that allowed participants to create virtual identities. They could observe their peers' gestures and movements; however, their facial expressions were absent. The lack of non-verbal communication can limit the shared understanding or vice-versa – support project-oriented actions. HENDERSON (1998) highlighted the importance of graphic communication in the collaborative design practice. MIVR goes beyond visual content, offering an immersive experience where non-experts can quickly prototype their ideas, even if they do not have a design background, as stated by GEORGE et al. (2017) and LIU & WANG (2019). Several challenges highlighted by JOHANSSON & ROUPÉ (2024) still exist. Still, new stand-alone MIVR software development allows for shorter learning curves, smoother interoperability, and faster rendering performance, primarily when the collaboration focuses on the spatial dimension rather than realistic visualization. Nevertheless, glitches, motion sickness, and other hardware limitations occasionally interrupt immersion, diminishing the MIVR engagement.

5 Conclusions and Outlook

The main insights confirm that MIVR holds significant promise for streamlining the landscape architecture design process through collaboration and teamwork, engagement and interaction, and navigation and adaptability. MIVR enables immediate collaboration, enhances real-time synergies, and changes the distribution of traditional designer/non-designer roles. The immersive environment serves as a drive to stimulate creativity and motivation. Gamification of the experience brought down communication barriers. Our research proved that MIVR facilitates collaboration between design and non-design participants. Participants with prior experience in traditional modeling tools preferred them for detailed work, raising the need for smoother integration between MIVR and established workflows. In this study, participants had the advantage of visiting the real site, which may have contributed to their spatial understanding and design process. This raises a question for future research: Would the outcomes differ if participants relied solely on the MIVR model without real-world site experience? Exploring this scenario could provide insights into the potential and limitations of MIVR as a standalone tool in streamlining the design process in landscape architecture. Future research should consider how these tools can be integrated into various scales and contexts, within professional applications and training programs, and in education curricula design.

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References

ANDREASEN, M., HANSEN, C. & CASH, P. (2015), Conceptual Design-Interpretations, Mindset and Models, Conceptual Design. Springer International Publishing, Cham, Switzerland. http://doi.org/10.1007/978-3-319-19839-2_1.

AZIZO, A. S., ALI, K. N., A.IAHAD, N., MOHD, N. I., MAT DZAHIR, M. A. & ABDUL RAHIMAN, N. (2022), A Methodology to Evaluate the Effectiveness of Designers' Cognitive Process When Using Multi-User Virtual Reality. Built Environment Journal, 19, 60-66.

BEHZADFAR, M., FAIZI, M., ASL, S. R. & BEIKLOU, B. H. (2010), A New Collaborative Pattern Between Landscape Architects and Urban Designers in Environmental Design. American Journal of Environmental Sciences, 6, 344.

CONTRERAS-ESPINOSA, R., FRISIELLO, A., EGUIA-GOMEZ, J. & BLANCO, A. (2022), Co-Creation, Co-Design, and Co-Production: Enablers and Barriers for Implementation and Use of Digital Technologies. Communication and Applied Technologies: Proceedings of ICOMTA 2022. Springer.

FENG, Q., LUO, H., LI, Z., LIANG, J., LI, G. & YI, Y. (2024), Creating an Immersive Virtual Reality Game Space for Multiuser, Synchronous Co-Located Collaboration: Design Considerations and Influencing Factors. Applied Sciences, 14, 2167.

GEORGE, B. H., SLEIPNESS, O. R. & QUEBBEMAN, A. (2017), Using Virtual Reality as a Design Input: Impacts on Collaboration in a University Design Studio Setting. Journal of Digital Landscape Architecture, 2, 252-259.

HENDERSON, K. (1998), On Line and On Paper: Visual Representations, Visual Culture, and Computer Graphics in Design Engineering. MIT Press.

HILL, D., GEORGE, B. & JOHNSON, T. (2019), How Virtual Reality Impacts the Landscape Architecture Design Process During the Phases of Analysis and Concept Development at the Master Planning Scale. Journal of Digital Landscape Architecture, 4, 266-274.

JOHANSSON, M. & ROUPÉ, M. (2024), Real-World Applications of BIM and Immersive VR in Construction. Automation in Construction, 158, 105233.

KEUNG, C. C. W., KIM, J. I. & ONG, Q. M. (2021), Developing a BIM-Based MUVR Treadmill System for Architectural Design Review and Collaboration. Applied Sciences, 11, 6881.

LEE, J. W., KIM, J. D., GO, J. H., JANG, Y. S. & LEE, Y. G. (2023), Developing a Human Behavior Simulation Technology Based on Multiuser Immersive Virtual Reality in an Atypical Architectural Design Process. International Conference on Human-Computer Interaction, Springer, 235-240.

LIU, Y. & WANG, B. (2019), Application Research of Virtual Reality Technology in Landscape Design. Journal of Physics: Conference Series. IOP Publishing, 042050.

PERRY, M. & SANDERSON, D. (1998), Coordinating Joint Design Work: The Role of Communication and Artefacts. Design Studies, 19, 273-288.

REITH, A., SZILÁGYI-NAGY, A., BALOGH, P. I. & KERESZTES-SIPOS, A. (2021), Report of a Remote Participatory Design Process to Renew a Schoolyard During COVID-19. Journal of Digital Landscape Architecture, 6-2021, 414-421.

ROVIRA, R. (2016), Varying Degrees of Impermanence: Art and Landscapes as Critical Provocation. Innovations in Landscape Architecture. Routledge.

SHERMAN, B. & JUDKINS, P. (1992), Glimpses of Heaven, Visions of Hell: Virtual Reality and Its Implications. Hodder & Stoughton.

TEA, S., PANUWATWANICH, K., RUTHANKOON, R. & KAEWMORACHAROEN, M. (2022), Multiuser Immersive Virtual Reality Application for Real-Time Remote Collaboration to Enhance Design Review Process in the Social Distancing Era. Journal of Engineering, Design and Technology, 20, 281-298.

TRAN, D.-H., PHAM, D.-T. & HUYNH, P. H. (2023), Metaverse Immersive Virtual Reality Enhances Multiple Collaboration in the Construction Design Review Phase. The International Conference on Sustainable Civil Engineering and Architecture. Springer, 576-583.