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Literature Review

VR applications in the architectural and spacial design process

Virtual and augmented reality technology provides new capabilities within architecture and other spacial design practices. Because of its current rapid-emergence, VR is a largely un-tapped and highly novel technology, with slow adoption in the practical design process. While VR technology affords many benefits, it also has significant challenges which defer design practitioners from readily implementing it into the standard design procedure.

One of the most significant features of VR is the immersive feeling of "being in the real world" (Song & Huang, 2018). In other words, users are able to experience the existence of a virtual environment; In the context of spacial design, VR can be used to directly construct a landscape scene. Based on a literature review by Strand (2020) which focuses on the benefits and challenges of VR use in architecture, design, and engineering, there are a few main benefits associated with the implementation of VR. The first is to gain a better understanding of the size and proportions for a design task. VR allows designs to be rendered and viewed in full scale as opposed to being limited to small models or sketches (Strand, 2020). This can allow users to gain a better understanding of complex design-related issues (Gyldendahl, 2017). It also allows users to feel the space and atmosphere of a structure in a realistic way before anything has been build (Racz & Zilizi, 2018). This is not only helpful for designers to gain insight on the size and emotional effects of a built environment, but it can also help customers experience the environment and provide feedback before costly construction (Song & Huang, 2018).

The second benefit is the ability of VR to enhance motivation and problem-solving. VR provides a motivating, fun, and inspiring experience (Strand, 2020). The novelty of VR has been said to be enough to motivate students. However, this benefit is turbulent, as it is unclear whether motivation diminishes along with the novelty factor given routine exposure to VR technologies. A study done by Özgen, Afacan, and Sürer, (2021) evaluated the usability of VR by comparing the differences between a VR-based design group and paper-based design group. Their results demonstrated a statistical difference in effectiveness between the two groups when comparing

the success of two types of design problems. It suggested that VR can strongly enhance problem-solving activities and may be an excellent resource for architectural design education.

A third benefit is the possible of VR to materialize one's ideas through digital porotypes (Strand, 2020). Studies showed that students were satisfied that their work would not just be another abstract and unimplemented idea upon experiencing their designs through a virtual technology (Halabi, 2019). A VR design system developed by Chowdhury and Schnabel (2020) allowed non-expert designers to product 3D artifacts and visualize pre-conceived design ideas. This allowed empowered non-expert designers and laypeople to collaborate with designers in the early design stages and participate in their local or neighborhood environmental design moves (Chowdhury & Schnabel, 2020). It is also possible for VR to invoke creativity for designers through the materialization of one's ideas because designers may not have an intuitive scene or display, so their thinking is confined. With VR, designers are able to move within the materialized scene, and it can inspire creative thinking which improves the overall design (Song & Sijia, 2018).

Despite these compelling advantages, there are significant drawbacks to the implementation of VR within the scope of the architectural and environmental design process. Aside from the cost of equipment, one of the most widely reported challenges against its implementation is the possibility of VR to limit the design process (Strand, 2020). VR may provide unsatisfactory sketching opportunities or lack the affordances and functionalities necessary. For example, virtual technology can only construct a landscape or building as far as possible in term of technology (Song & Huang, 2018). Contrary to the study done by Özgen, Afacan, and Sürer, (2021), Kim et al. (2020) found that participants who completed a design task with pencil and paper before working in VR outperformed participants who started off in VR based on various assessments of creativity.

Additionally, participants may be unable to exploit the full potential of VR. The use of VR technologies requires users to expend much energy in order to control and navigate the system, increasing their cognitive load and distracting from the primary task (Strand, 2020). Understanding of the technology and training may be necessary, particularly in order to become comfortable with the device and its affordances, which takes time and effort. According to Strand (2020), "it is clear that VR is often used for realistic simulations or skill-training purposes, but it is important to spend enough time on the simulations in order to improve skills."

Furthermore, users must also have adequate training in order to maneuver the occurrence of software or hardware usability issues.

Certain devices, such as head-mounted displays, or HMDs, also limit the number of users allowed in an environment at one time, whereas traditional tools can be easily viewable and experienced simultaneously by multiple viewers.

Finally, VR systems may also generate diverse physiological and psychological effects (Strand, 2020). For one, HMDs can be quite heavy, causing discomfort or dizziness for users. Devices may also be difficult for people with glasses, motion sickness, or epilepsy to use.

It is worth noting that while the articles reviewed mainly focused on the uses of VR in the design process, some researchers argue that VR implementation should focus more on stimulating human actions and real conditions rather than design rendering. For example, Zhang and Codinhoto (2020) argue for the use of VR towards understanding the conditions of the elderly and physically impaired individuals using simulators. Vieira et al. (2020) have also used AR in understanding how public parks can better support the needs and preferences of older adults in local communities.

There are many advantages and disadvantages to the implementation of VR in the environmental design process. Furthermore, there is still much more room for research and development on the utility, effectivity, and implementation of VR in the design sphere.

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