Assessing the Impact of Virtual Reality on the Planting Design Process

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Abstract: Virtual reality (VR) has been evaluated as a design tool in a variety of different tasks but incorporating it in planting design workflows has not been thoroughly researched. This paper describes the creation of a VR workflow to facilitate planting design natively in VR and evaluates students' experience designing in VR. Students responded positively to the use of VR and believed that it helped improve their planting designs. Evaluation of the designs suggest that improved spatial awareness had direct impact on student design decisions. However, students reported a steep learning curve technologically, and some frustration with a lack of precision within the VR environment.

Keywords: Virtual reality, visualization, planting design

1 Introduction

1.1 Virtual Reality

Landscape architects have historically relied on two dimensional plans or physical models to convey their design intent, but these methods often fall short in conveying the scale, depth, and sensory experience of the landscape or can be costly to make. Advances in visualization technologies, most notably digital modeling, have improved the fidelity of visuals, but these remain an external method for viewing and understanding a design. Over the last few years, the emergence of virtual reality (VR) has allowed designers to be virtually immersed in their designs, representing a fundamental shift in how we interact with our design ideas. If the process of designing is similar to a conversation between the designer and the design concept, as SCHÖN (1985) suggests, then an increased understanding of the total spatial environment would logically improve the dialogue in the process.

Research thus far has indicated that this is the case. DE FREITAS and RUSCHEL (2013) noted that VR improved design visualization and collaboration significantly, while GEORGE et al. (2017) facilitated a more immersive and interactive design process amongst team members. The findings of PORTMAN et al. (2015) suggested that VR can enable DESIGNERS to develop novel design ideas. Similar findings were found by HILL et al. (2019), including that the benefits of VR were consistent across different site scales. Fundamental to nearly all these benefits is enhanced spatial awareness facilitated by VR that leads to improved spatial perception of design decisions (PAES 2017).

1.2 Planting Design

Planting design is recognized as one of the more complex tasks that a landscape architect engages in (ROBINSON 2017). This is due to a number of factors, including the sheer diversity of plant species available, the multitude of aesthetic choices, environmental issues, and functional characteristics that must be considered, as well as the traditional design factors such as a form, texture, color, scale, repetition, etc. Although historically different planting design

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styles have varied in how much complexity and diversity they have, much of the modern era of landscape architecture has been dominated by the relatively simplistic planting styles of the modernist and post-modernist era (ROGERS 2001). TUNNARD (1938) placed an emphasis on functional landscapes that relied on legible lines and forms and a minimal number of species. Tunnard's position would later be championed through the highly influential work of landscape architects such as Russel Page, Garrett Eckbo, and Roberto Burle Marx, and later in the vein of Lawrence Halprin and Peter Walker (BYRD & MORRISON 1999). Treating the form of planting beds and plant masses as any other element of the landscape, these planting designs are relatively easy to conceive and visualize. However, beginning in the 1990s, significant changes in planting schema began to occur. Wolfgang Oehme and James van Sweden were noted for planting designs that eschewed massed plantings and dramatically increased species diversity. Perhaps the most noted planting designer today is Piet Oudolf, whose ecologically-inspired meadow plantings are a cornucopia for the visual senses (ROBINSON 2017). The work of these new wave designers has dramatically transformed modern planting design and amplified the complexity of the planting design process. As this complexity increases, there is an increased value in providing more advanced ways to visualize the design choices being made.

Virtual reality's ability to provide the designer with immediate visual and spatial feedback on design decisions has the potential to provide landscape architects a more holistic understanding of their design decisions and it is hoped that integrating VR into the planting design process can do the same. However, little research has explored the viability of VR on planting design decisions. GEORGE et al. (2022) found that the using VR to place trees in a design led to increased plant density and improved visual outcomes. However, the remainder of the research in this area has focused on the use of VR as an evaluative tool for planting design (ELLEFSEN 2022, WANG & LIU 2023). Furthermore, there is a lack of existing tools that easily facilitate the planting design process in VR. Thus, there is a need to develop a workflow and evaluate whether earlier affordances identified for VR translate into the complex planting design process.

2 Methodology

The goal of this study was to evaluate the use of VR as a primary design tool in the planting design process, as opposed to an evaluative tool, and if it helped students to better understand the complexities of their planting design. To do this, a workflow was developed that integrated VR into the planting design process with AutoCAD, Land FX, SketchUp, VR Sketch, and Twinmotion. A residential site basemap file and 3D model was synched between AutoCAD and SketchUp, utilizing Land FX's 3D Connection tool to automatically update changes to plant placements across the software platforms (Fig. 1). Students were provided a virtual plant nursery in SketchUp that consisted of 2D, face-me style plants that were accurate in appearance and size to the individual plant species. The virtual plant nursery was curated in collaboration with the course professor from a list of drought tolerant plants suitable for the local USDA plant hardiness zone. This list was created to reduce the project workload to allow students more time to learn the workflow and experience designing in VR instead of choosing plant material.

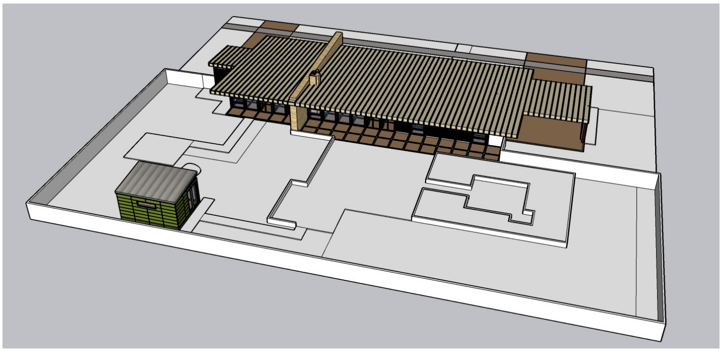

Fig. 1: Site model students received for use in VR

The majority of the face-me plants were custom made with high resolution images of the actual plants in the virtual plant nursery in order to achieve as high accuracy and fidelity as possible (Fig. 2). Each plant was scaled to the correct dimensions based off of consultations with local horticultural experts. The use of 3D models instead of face-me plants was evaluated but ultimately rejected because of an unreliability in importing multi-polygonal 3D models of plants from SketchUp into Twinmotion. If not using Twinmotion as a final renderer, typical 3D plant could be used.

Students utilized the VR Sketch plug-in for SketchUp which enabled them to view and edit the 3D model within VR. This allowed students to move and place plants natively in VR, where they could visually and spatially evaluate their design decisions. Placements of the plants in VR were then synched back to the AutoCAD file via the Land F/X 3D Connection. Once the final design was decided upon the 3D model was then imported into Twinmotion for final rendering. This workflow allowed students to utilize VR in the design process as well as create final construction document planting plans and client ready renders almost simultaneously.

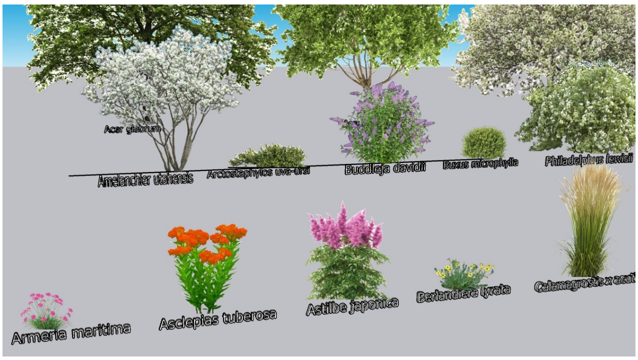

Fig. 2: Custom face-me plants in the digital nursery as viewed in VR Sketch

For the project, students worked in pairs, with one student working with the VR Sketch plugin in the VR headset, and the other working in SketchUp on the workstation. Students visually and verbally communicated and collaborated on design decisions, with the student in the VR headset taking the lead. The students regularly alternated between the VR headset to ensure that both students had ample time to view and edit the planting design in VR. Students were given two weeks to complete their design, which included 12-hours of in-class work time to get help from the course professor if needed. They also had access to the VR headsets and lab computers outside of class time for the duration of the project. Prior to the project, the students completed a brief design vignette using the same workflow to give them an opportunity to become familiar with the process and VR technology before starting the project.

Prior to beginning the project, the students were also given a pre-survey to gather information about demographics and previous VR experience, and students' current design workflow preferences. After the study, a post-survey assessed students' experiences and preferences regarding the use of VR for planting design. The surveys primarily used 7-point Likert scales and open-ended questions. The course professor evaluated the student designs to identify trends in comparison to other work done by students throughout the course.

3 Results

The results of the pre-survey showed that 56% of students had used a VR headset before, however, of those, 90% reported that they used VR less than monthly. Students reported that they were comfortable designing in plan view (6.19), but less comfortable designing using sections or perspectives (5.16 and 4.56 respectively). Also, most students somewhat agreed they were aware of the 3D character of their design work (4.9).

The post-survey revealed mixed results on the impact of VR on the planting design process. Student awareness of the 3D character of their design rose to 5.72 and students largely agreed that VR made them more aware of the 3D character of their design (5.72) and that it improved their ability to visualize their planting plan (5.38). However, students were less certain that VR altered their planting design approach (4.55). Despite this, the majority of students reported that they would use VR again for planting design (5.76).

Students were also asked which tasks they found easier, using either the traditional plan view planting design method or the VR method. Students preferred to use VR to understand the spatial components of the planting design and to interact with the planting design. However, there was no preference related to refining the planting plan (Fig. 3).

Students who reported in the post-survey that they were more aware of the 3D character of their design was strongly positively correlated with VR improving their visualization of their planting plan ($r=.713$, $p<.001$) and VR altering their approach to planting design ($r=.518$, $p<.01$). Similarly, there was a strong positive correlation between students reporting they would use VR again for planting design and VR improving their ability to visualize plants ($r=.821$, $p<.001$) and VR altering their approach to planting design ($r=.721$, $p<.001$).

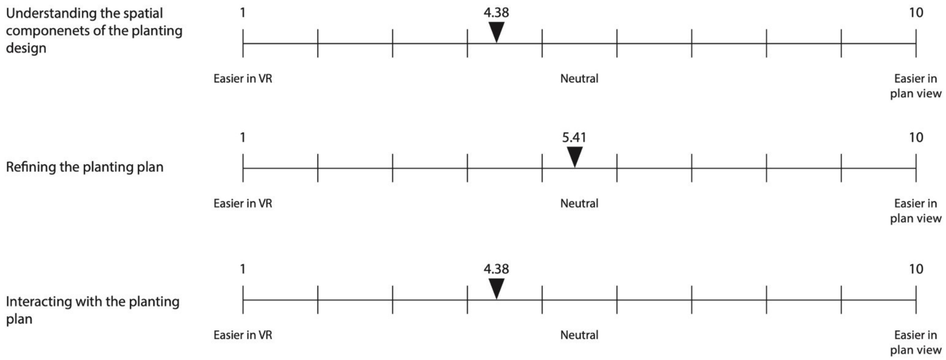

Fig. 3: Student preference for completing tasks in either VR or using traditional methods

Post-Survey Benefits

Rank	Code	%
1.	Visualization of the area / Spatial Awareness / Scale	20.7
2.	Explore the design 'in person'	15.1
3.	Visualize plant height, density, and depth	15.1
4.	'Feel' of the area	13.2
5.	View of color combos of plants and materials	7.5
6.	Design / manipulate in person	7.5
7.	See the mature design	5.6
8.	Client exploration / Ease of viewing	5.6
9.	Required deeper though on plant plaement	3.7
10.	Design exploration / freedom	3.7
11.	Identify problem areas sooner / immediate edit feedback	1.8

Fig. 4: Coded responses from students of perceived benefits using VR in planting design

Students answered open-ended questions about the benefits they saw using VR for planting design. The comments were coded to identify the areas where students found VR to be most beneficial to the planting design process (Fig. 4). Constraints mostly revolved around the learning curve and technical issues.

In evaluating the student designs, the course professor identified two trends in the designs produced in VR. The first was that the planting designs had a greater density of plantings compared to other designs completed by the students without VR. The second was that students utilized understory plantings much more in the VR designs (Fig. 5).

Fig. 5: Sample images of completed student planting designs in Twinmotion

4 Discussion

Previous studies with VR have found wide application for the use of VR in various aspects of design. The findings of this study suggest those benefits extend into the planting design process, though with differing impacts than seen applying VR elsewhere. Students saw particular benefits in understanding the spatial comprehension of their planting design. This benefit can be particularly impactful, especially for young designers, because a planting plan is highly complex both spatially and visibly. VR was also particularly beneficial in this regard as is evidenced by two of the top five coded comments being related to these complexities: *understanding the height, density, and depth of the planting design* and *viewing the color combinations in the planting design*. These benefits are also tied to the course professor's observation of plant density and understory plantings, which were likely impacted by students' ability to better visualize the spatial interaction between plants. Students often have problems visualizing how plants interact and overlap horizontally and vertically in a design and therefore fail to adequately plant underneath trees or large shrubs. The use of VR appears to have enabled students to recognize these visual gaps in their planting design and adjust accordingly to ensure a more cohesive design throughout.

Given these results, it is somewhat surprising that students did not strongly report that understanding the spatial component of the planting design was easier in VR than using a traditional plan drawing. While students did prefer VR, it was only by a modest margin. Why this is the case is uncertain. In comparison to many other studies on the use of VR in design, the reported benefits from this study are not as pronounced. This may be explained by a number of reasons. Foremost, the workflow involved multiple applications and plug-ins, making it more technically challenging than many other uses of VR reported in studies. Students were required to learn a new hardware device (VR headset), a new modeling plug-in (VR Sketch), and a new renderer (Twinmotion). If a native VR tool for planting design had been available, it is possible that students would have reported stronger benefits. A second consideration is the nature of planting design, which is particularly complex and detail-oriented. The character of VR and the VR Sketch interface can be argued to favor more conceptual design work where highly accurate placement of elements is less of a concern. A few students noted that moving objects, adding plants and otherwise refining and editing the design was notably easier outside VR, probably due to the precise placement limitations and the user interface of VR Sketch not being as robust as the desktop version. While the student working on the computer workstation could fine tune the placement of plants, the difficulty of doing this natively in VR may have also reduced the perceived benefits of VR.

Many students commented that working collaboratively in VR and on the computer allowed for creative freedom and the ability to collectively refine their designs in real time. One student said that the VR and computer collaboration created an opportunity for dynamic teamwork. They also thought it was informative to see how the different programs can have multiple workflows and design tools being use at the same time. Finally, students who reported the most benefit from VR are those that experienced the most improvement in visualizing their planting design. These students were more likely to report that VR altered their approach and are more likely to use VR again. This again implies that VR might be well suited in helping young designers to better understand planting design decisions.

There are several practical limitations in this study. Students felt precision in VR was not as easily achieved. This can be addressed by the partner on the computer finalizing the exact placement while the VR user places the plant in their approximate final positions. Students did note that after the initial learning curve precise placement became easier in VR. Another limitation is the cost of both the hardware and the software. Meta Oculus headsets were chosen due to their lower cost compared to other VR headsets and already having several available in the classroom. The selection of software was also based upon practical availability, due to the used programs providing educational licenses. This workflow was specifically built around those programs and would need to be modified to use other software. Other software connections were not explored, but other final rendering programs could easily be introduced into the workflow in place of Twinmotion.

Some of the implementation limitations that were identified throughout the study were collecting accurate/adequate plant models to use in Sketchup – either face me or low-poly. Assuming accurate models are not available, it could be time consuming to compile a model library. Students noted that it was frustrating going from accurate models in SketchUp to ‘available’ models in Twinmotion, where it did not as accurately reflect their planting plan. Students did not report motion sickness was not an issue with these programs, and due to all work being done seated, space was not an issue as often reported with other VR studies.

5 Future Work and Conclusions

This study demonstrated that VR can be an effective tool for planting design. The capacity of VR to visualize a complex landscape planting can provide the designer with immediate valuable feedback on their plant selection and placement. Students responded positively to the ability of VR to help them understand their planting design decisions through improving their spatial awareness of their design. While this study mainly looked at perceived benefits by the designer, additional research in this area will want to conduct more objective assessment of planting design outcomes using VR to better determine specific impacts VR has on outcomes compared to traditional methods as well as applying outside assessments beyond instructor evaluations. Future studies could expand beyond students and involve industry professionals that could provide different insights.

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