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Implementing Virtual Reality Headsets in Design Education: Identifying Springboards and Barriers to Success

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Abstract

While Virtual Reality (VR) is now widely used as a final design presentation tool, little research focuses on the role of VR during design development processes in design education. However, properly positioned and pedagogically researched VR holds great potential for helping students make better design decisions to support end-users with diverse needs. This research seeks to connect the value of VR as not only a presentation medium but also as a "perspective taking" tool to help students develop better design solutions. Undergraduate Interior Design students (n=15) were recruited to experience their already completed studio projects of a retail store design as a VR character in a virtual wheelchair. Each participant was asked to assess the effectiveness of their design solution for wheelchair users before and after the intervention. The interactions students had during their VR sessions were recorded and content analyzed for emerging themes. Although the sample size was small to achieve statistical power, qualitative findings revealed numerous perceptual shifts as students identified problems for wheelchair users in their design solutions.

Keywords: virtual reality, education, interior design

Introduction

Virtual Reality (VR) is now ubiquitous as it has become an alternative tool to communicate ideas (Jarvenpaa, Leidner, Teigland, & Wasko, 2007, as cited in Chaturvedi, Dolk, & Drnevich, 2011). VR provides an interactive experience while users navigate through their designed creations (Kaleja & Kozlovská, 2017). Although VR is becoming widely used by design professionals as a final presentation tool, little to no research exists on the role of VR to support in-process work and design development for end-users with more specialized needs—people who use wheelchairs, people with low vision, or children (Teklemariam, Kakati, & Das, 2014, p.121; Neubauer, Paepcke-Hjeltness, Evans, Barnhart, & Finseth, 2017). While designers and, especially, design students often make accessibility decisions based on an "codes only" approach, the interactive nature of VR can help them better assess nuances in the end-user experience of their designed environments. The incorporation of this technology can fill the knowledge gap between theoretical materials and practice that is usually difficult to demonstrate in design education (Teklemariam et al., 2014).

The first-person perspective VR generates can give designers a more accurate sense of elements commonly linked to qualitative indicators, like furniture sizes, lighting conditions, materials, and clearances (Kaleja & Kozlovská, 2017, p.115). With the ability to experience their design through different characters, VR can help designers consider the difficulties and special accommodations of such user groups (Neubauer et al., 2017). Thus, if properly positioned, VR holds great potential for design students to understand a more holistic end-user experience, especially for users with different needs (Kaleja & Kozlovská, 2017, p.115; Neubauer et al., 2017).

Present Link Between VR and Design Education

Currently, students utilize computer aided design (CAD) tools to create 3D virtual models that aid in visualizing the space and expressing the overall impression of their design solutions. Although students can display what they intended with multiple views and outputs, some design aspects are difficult to understand with current tools (Kaleja & Kozlovská, 2017, p.110). VR demonstrates the ability to complement existing design education practices by allowing students to interactively experience their 3D models in real-world scale with high levels of detail, which also speeds up the design process for feedback and mistake detection (Dvorák, Hamata, Skácilík, & Beneš, 2005). However, there is currently a gap between the CAD tools and VR programs that hinders the direct linkage between VR and design education.

Since the VR operates with a different system than the CAD files, additional knowledge and time is required to convert CAD files to VR successfully (Dvorák et al., 2005). The current lack of more straightforward conversion tools and the absence of a streamlined workflow between the two programs increases the difficulty of incorporating VR into design education fully. The lack of access to and the current price of the VR devices are also factors that contribute to the challenge of integrating VR into design education (Kaleja & Kozlovská, 2017, p.110; Dvorák et al., 2005).

Research Gap

While many studies have examined CAD technologies in design education (Wake & Levine, 2002; Teklemariam et al., 2014) or examined the implementation of VR in other disciplines (Onyesolu, Eze, & Schmidt, 2011), little to no studies have examined the potential role of VR in interior design education. This paper seeks to bridge the gaps between VR and the design development process in design education to explore the potential of VR as an active learning tool. The current study was designed to test how the application of VR in design studios would facilitate learning and to answer the following questions:

- How would the students shift their perceptions after virtually experiencing their proposed design solutions through the eyes of wheelchairs users?
- What potential benefits can VR impart to student design thinking processes?
- What are some emerging challenges that needed to be overcome to meaningfully incorporate VR in design education?

This paper aims to prime the discussion about the possibility of incorporating VR into future design curricula.

Methods

Junior and senior interior design students (n=15) were recruited through their studio courses with permission obtained from course instructors. Each student was asked to quantitatively assess how well he or she addressed different end-user needs on a previously completed studio project, both before and after the VR intervention. For the intervention, each student was asked to navigate through and experience their proposed design solution in VR using a simulated character in a wheelchair. While in VR, each student was asked to verbalize any challenges they experienced, or issues they identified their design solution as they rolled around and interacted with the space. All responses and VR interactions were videotaped and content analyzed.

The study was conducted with seven main steps as outlined below:

I. Participants' 3D CAD files (REVIT Format) of a previously completed project were collected.
II. Participants' 3D files are converted and imported into Unity.

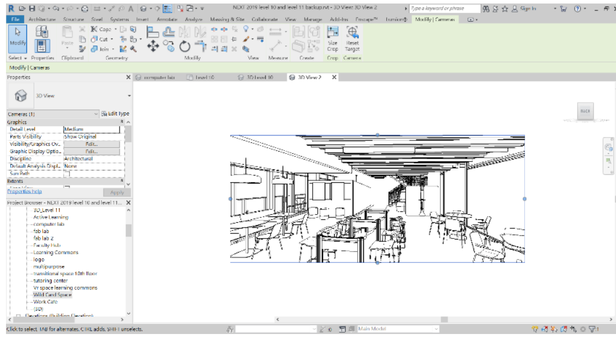

Figure 1. 3D CAD/Revit File Collected from Student

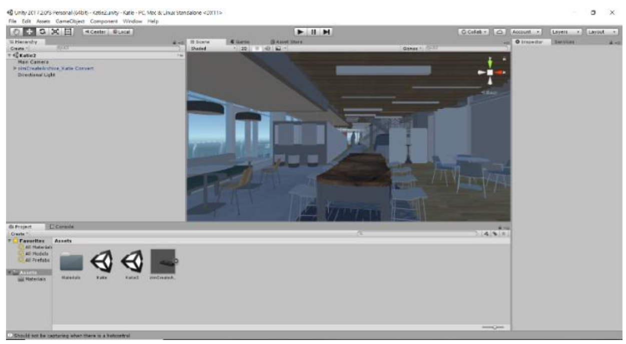

Figure 2. File Converted and Imported into Unity

III. A computer workstation with a VR headset and controllers was set up in a room adjacent to the interior design studios.

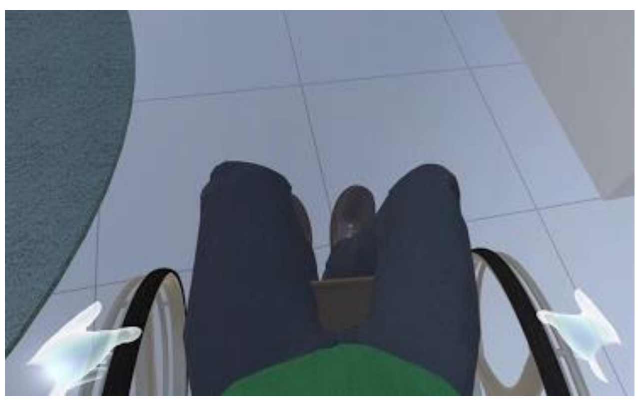

Figure 3. Virtual Wheelchair Character

IV. During studio time, each student was invited into the room and assessed how well their project addressed the needs of wheelchair users.

Figure 4. VR Environment of Student's Design Project

V. Students were instructed to put on the Oculus Rift CV1 VR Headset and Hand Controllers and directly started to navigate around in their design project using the Virtual Wheelchair. Students were videotaped during this phase and asked to articulate any changes they would make as they experienced the spaces.

Figure 5. Student Experiencing their Design in VR

Figure 6. Student Reaching for Objects in VR with Hand Controllers

VI. After the VR intervention, each student was asked again to assess how well their project addressed different user needs, as well as what elements would they now consider while designing for wheelchair users. The whole data collection process took approximately 20 - 30 minutes for each participant.

VII. The recordings were transcribed, and content analyzed for reoccurring themes.

Results

The results of this study contain four different parts, one set of quantitative data and three sets of qualitative data that were content analyzed.

1. Quantitative Assessment Pre and Post Intervention

Each participant was asked to rate their design twice on a scale 1-7, before and after the VR experience, on how well do they think their design addressed the needs of wheelchair users, with one being the least successful and seven as the most successful. The responses are shown in the figure below:

Table 1. Student Ratings of Their Design Before and After VR

Participant	Pre-VR	Post-VR	Difference
1	7	4.5	-2.5
2	5	2.75	-2.25
3	5	4	-1
4	5.5	5	-0.5
5	5.5	5	-0.5
6	5	4	-1
7	6	6	0
8	3.5	2	-1.5
9	4	4.5	0.5
10	4.5	4	-0.5
11	5	4	-1
12	5.5	4.5	-1
13	5	5	0
14	5	4	-1
15	7	4.5	-2.5
Total	78.5	63.75	-14.75
Mean	5.233333333	4.25	-0.98333333
Standard Deviation	0.942388051	0.949623986	0.89874251

Of the 15 participants, 80% have decreased their ratings after seeing their design in a virtual environment, 13.33% gave the same rating, and 6.67% increased the rating. On average, the ratings drop from 5.23 to 4.25, which is about 14% lower than the initial rating. Due to a limited sample size and statistical power comparative statistics were not conducted.

2. Qualitative Assessment Pre-Intervention

Participant were also asked to articulate in a free response fashion, both before and after the VR intervention, on what design factors they would consider while designing for wheelchair users. Student responses were videotaped and transcribed. Constant analysis was conducted to categorize reoccurring elements. The responses are shown in the figure below:

Table 2. Design Factors and Percentage of Students Mentioned Before and After VR Intervention

Design Element	% Mentioned Pre VR	% Mentioned Post VR
Furniture		
Height	53%	60%
Varying Height		20%
Sightline		20%
Provide Options	26%	26%
Able for Wheelchair to Roll Under	13%	33%
Circulation		
Width	46%	60%
ADA Guidelines		
Follow Guidelines	46%	13%
Design More than Guideline		40%
Space		
Similar Space	33%	26%
More Inclusive Space		33%
Open Space	20%	26%
Floor Level Changes	33%	13%

Prior to looking around in the VR environment, the eight common factors students mentioned they would consider and the percentages of students out of the 15 that did so are as follow: the height of furniture placement (53%), the width of circulation paths (46%), following ADA guidelines and relating codes (46%), providing similar spaces for wheelchair users (33%), floor level changes (33%), providing different seating types (26%), having open space (20%), and considering the ability for wheelchairs to roll under the furniture (13%).

3. Qualitative Assessment Post-Intervention

For the data set after the VR experience, additional different factors emerged as common themes that students would now consider. While the percentage of students that mentioned they would consider the height of furniture raised from 53% to 60%, there are also new factors such as sightlines (20%) and the variation of height (20%) students would now consider. The percentage of students mentioning the width of circulation paths also increased from 46% to 60%, with an additional factor of reviewing the distance of the path needed to reach a space where they can comfortably turn around in their wheelchair. There is a drop from 46% to 13% of students who mentioned to follow ADA guidelines and codes. On the other hand, 40% of the students expressed that they now understand the ADA guideline is a minimum requirement and should try to design above it. For factors relating to furniture, an additional element arises as considering the furniture arrangement, providing different seating types remained at 26%, and the ability for wheelchairs to roll under rose from 13% to 33%. The students who considered providing similar spaces drop from 33% to 26%, but instead, 33% of students would now consider factors to allow wheelchair users to be more included. The percentage of students considering floor level changes drop from 33% to 13%, and the percentage to have more open space increased by 6.67%.

4. Qualitative Assessment During the Intervention

Table 3. Design Factors and Percentage of Students Mentioned During VR Intervention

Design Element	% Mentioned Pre VR
Furniture	
Change Seating Arrangement	20%
Provide Different Seating Options	20%
Change Furniture Selection	60%
Stools Too High	40%
Space	
Not Enough Turning Space	13%
Circulation Path Difficult to Navigate	27%
ADA Corridors Too Tight	53%
Height	
Elements Too High to Reach	53%
Sight Issues	13%
No Space to Roll Under (Counter/Table)	33%
Need to Vary Counter Height	40%
Flooring Change	20%
Design Excluding Wheelchair Users	40%
No Sense of Belonging	33%

The final set of the quantitative data was collected while students were navigating through their spaces in the VR environment and were asked to articulate any problems or issues they encountered and what they would change in their design solution. Through content analysis, the reoccurring factors the students consider can be breakdown into a few categories: furniture, spacing, height, flooring, and experience. Within the furniture category, 20% mentioned to change their seating arrangement, 20% suggested to give different seating options, 60% mentioned that they need to move or change one or more of their furniture selection to give more space in the circulation path, and 40% mentioned they have stools that are too high. Some common themes mentioned by students at some point during their experience regarding to the spacing and the percentages are as followed: 13% found that they did not have enough room to turn, 27% found circulation paths that are difficult to navigate through, 33% found the corridors they designed to the ADA guidelines were perceptually tight. In relation to height, 53% noticed an element or more in the design to be too high to reach, 13% had sight issues resulting from placement height, 33% identified issues with tables and counters for wheelchair to roll under, and 40% concluded they need to vary the counter height with a lower, more accessible end. Among the 27% of students that mentioned about flooring, 75% decided to take out flooring transition changes. 40% of the students also found parts of their design to be excluding the wheelchair users by not providing the same experience, and 33% of not having a sense of belonging.In addition, 60% of the students realized a difference in the scale of objects than what they thought it would look like, including furniture looks bigger, ceiling condition looks higher or lower, or a customized element seems taller. One student also found out about a code issue while navigating around in VR.

Discussion

The quantitative and qualitative data revealed two general trends in student responses. First and foremost, an increase in number of factors that students would consider while designing for users with special needs. Second, a decrease in how successful they think their original design solution was tailored to wheelchair users. Although more data is needed in the future to obtain statistical significance, the current research displays the possibility that VR can aid students with their design decision and alter their design thinking. This is evident from the qualitative data where most students articulated a different point of view and a more comprehensive range of factors they would consider for wheelchair users in their design. Interestingly, although students displayed an understanding of ADA guidelines, many realized that the circulation paths they designed to fit the minimum ADA standards are still uncomfortable to move through, and articulated their desire to make the paths wider in their future design work to provide more comfort for wheelchair users. In addition, many students found some elements that their design solution felt larger or smaller than they intended—suggesting that VR holds great learning potential as a tool for understanding the design principle of scale. Although the models are built based on objective qualitative indicators, the scale of design elements in relation to one another is still difficult for students to assess with current CAD tools as the comparison is more subjective. The surprised responses from students experiencing the actual scale of their design throughout this research demonstrate VR's potential as both an objective and subjective learning tool. This experiential quality helped students quickly identify problems in code compliance, reach, sightlines, social inclusion, and safety simply by experiencing their space through VR.

It seems that VR excelled in providing students not only objective feedback, such as clearance, sightlines, and reach, but also more subjective impressions of social inclusion, navigational comfort, and sense of scale. This holistic experience demonstrates the potential that VR holds to provide rich design feedback and enrich the design education by filling in the gaps between theory and practice.

However, there are also several limitations that were presented throughout the study. These limitations, including file conversion and VR maneuvering challenges, need to be solved before the successful incorporation of VR into classrooms. In addition to the lack of conversion tools, the tedious process for file conversion would often result in errors despite the meticulous operation. For example, one of the materials designated on the chair turned into a flooring pattern, while in another, furniture seems to shift from its original position. In order to ease the process or create rapid conversion files, oftentimes, some other areas of the design are also sacrificed, such as the lighting condition altered, the part that is less important to the design to be cut off, or materials to be replaced with similar solid colors. Also, as with any new technology, the VR equipment requires a learning curve to get used to. Many of the students in the experiment did not have previous experience with the technology and were having difficulty maneuvering around. These limitations raise some more questions that need to be considered while utilizing VR in studios, such as to what extent should the VR environment be representative of the complete design, the time and educational value tradeoff in using the VR technology, and where VR should be positioned to maximize its benefit.

Conclusion

Currently, there is little research on implementing VR in design education. However, VR holds great potential in aiding students to understand the design process in a holistic way. The study demonstrated the possibility for VR to not only allows students to consider a wider range of factors by providing the opportunity for students to experience different user needs in a first-person point of view but also assists students in assessing subjective measures and realizing problems that are difficult to detect otherwise. Nonetheless, there are still challenges that hinder the direct incorporation of VR into design education. These problems will need to be solved, as well as future research studies on how to properly position VR into design curricula to maximize the potential of the technology to be conducted before the successful combination of VR in design education.

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