PhotograVR: Interactive Photography Education in Virtual Reality

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Author Note

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Abstract

The augmented, virtual, and mixed reality industry has grown significantly in recent years as technological advances improve user experiences. Together with an increasingly remote-work-enabled world, virtual reality (VR) presents an opportunity to provide immersive and interactive experiences no matter time nor place. In this project, we seek to evaluate the VR technology's ability to match the educational outcomes of traditional in-person hands-on learning. Additionally, we seek to compare the effect of social presence on learning outcomes of students in educational VR simulations with a human-like instructor versus an abstract non-human instructor. To meet these research goals, we develop a VR application that emulates a photography studio teaching lighting fundamentals. This paper covers the results of the first pilot test session and future considerations for refinement of the application.

Keywords: educational virtual reality, social presence, photography education, Oculus

PhotograVR: Interactive Photography Education in Virtual Reality

Technology companies are currently building and investing in an expanding metaverse; a digital environment that makes use of both virtual reality (VR) technologies. With a roughly $30 billion market size in 2021, the combined VR and AR market is predicted to grow to more than $250 billion by 2028 (The Insight Partners, 2022). As such, with the rising need for online educational experiences and evolving VR/AR technologies becoming more mainstream, it is likely that more classroom activities will be taking place in a variety of virtual environment spaces. Although much research has examined the topic of learning in digital environments such as video games and work-related training, most of these research projects have been conducted on environments that appear on flat-screen devices and seek to teach lower-level cognitive abilities. In other words, there is a deficit of knowledge on the topic of (a) learning in virtual reality environments and (b) how these environments may facilitate higher-level cognitive skills.

The main purpose of this project is to create a proof-of-concept VR program that teaches creative arts skills typically requiring expensive or extensive equipment. Under the guidance of Dr. Hocheol Yang in the Cal Poly Graphic Communication department, myself (Barrett Lo) and other graduating Graphic Communication student Katie Hollister create a program focusing on basic studio photography lighting principles, which traditionally requires a studio space, three or more professional lights, a camera, and a knowledgeable instructor. Virtual reality technology has the unique ability to provide an immersive simulation of 3D space that is interactive like the real world. Recent studies have found educational VR experiences to increase interest, self-efficacy, and aspirations in a given field (Makransky et al., 2020) and be no less effective when completed away from the classroom (Makransky et al., 2019). The effective VR implementation of a photography lighting curriculum that typically requires hands-on experience can serve as proof for future Cal Poly courses being translated to VR.

Background

Motivation

At the start of the COVID-19 pandemic lockdown in 2020, myself and many other Graphic Communication (GrC) students enrolled in the core course GRC 301 (Digital Photography and Color Management), which historically provides GrC students hands-on experience with professional studio lighting equipment and practices. Without the ability to meet in person and partake in this learn-by-doing lab, these students are now graduating less prepared than previous cohorts for industry-standard photo and video shoots.

The absence of hands-on learning during the pandemic is not unique to the Graphic Communication department; students of all disciplines at Cal Poly missed out on critical Learn by Doing experiences. Even without a pandemic, courses dependent on specialized space, physical equipment, and individual instruction often become impacted at the cost of both the institution and the student (Brown & Cruickshank, 2003). A virtual reality program that prepares for industry work, as well as an in-person lab, would allow more students to enroll in a course regardless of facility availability, equipment acquisition, instructors hired, or highly contagious diseases. It is important to create effective teaching materials for students to gain hands-on experiences, yet there is limited financial support for making effective educational VR experiences compared to those for entertainment, medical training, remote work, and military training purposes.

One of the reasons why VR experiences are likely to continue to rise in the future is because studies have shown that VR and augmented reality (AR) can enhance essential educational outcomes, particularly in motivation to learn (Hew & Cheung, 2010; Jensen & Konradsen, 2018; Merchant et al., 2014) because of the para-reality experiences afforded in immersive media content (Bracken & Lombard, 2004; Lombard et al., 2015; Lombard et al., 2017). With more online instruction taking place, there is a need to maintain (or exceed) the quality of learning between in-person and virtual formats. Hands-on activities may be performed and recorded by instructors for students to watch online but will likely be engaged at a passive level or active level at best according to Chi and Wylie's (2014) ICAP framework. Activities hosted in VR programs can require interaction and immersion from the student, elevating the minimum engagement level to active and extending to constructive or interactive at best.

Social presence

In addition to testing the efficacy of VR education for hands-on activities, another goal of this project is to compare learning outcomes between a scenario featuring a human-like instructor and one featuring an abstract non-human instructor. This second goal investigates the idea of social presence first introduced by Short, Williams, and Christie (1976) but applied to a context where the subject is immersed in a virtual space as in VR. Social presence can be defined as the subjective sense that another human is physically and mentally present in the same space. Research on the topic of social presence in immersive virtual reality points to participants being affected by the social presence of others, even if those others are actually computers rather than actual humans (Kyrlitsias, 2020). Through this project, we seek to determine the effects that social presence has on educational outcomes in VR.

Existing programs

Virtual reality technology has been of interest across industries such as manufacturing, entertainment, military, and medical. Virtual reality for education has been researched to a lesser degree but has the potential to increase access to and quality of education. Access is increased by only requiring a student to have a VR headset, which can store a plethora of learning topics and provide experiences that would otherwise be difficult to experience. Quality of education is increased by transforming online educational content into immersive and interactive truer-to-life lessons. DiVR 360, a marine sciences education VR program led by Cal Poly associate professor Crow White, allows participants to partake in the experience of conducting experiments deep underwater (Downey, 2022). The DiVR 360 program improves access to such underwater experiments, which would normally require special scuba licensure, and provides an engaging lesson thanks to its immersive 360 video.

A virtual educational photo studio has been created before. In response to a large number of students that were required to take an introductory photography course, and the lack of studio space and instructors to maintain the traditional education structure, faculty at De Montfort University in Leicester, England developed a 2D virtual photography studio simulation (Brown & Cruickshank, 2003). Made in the early 2000s with limited computing power and public computer literacy, the program had a fixed number of results based on the parameters that the user set. Results were shown in the form of images that the developers had taken in the real photo studio and set in the program. The students who participated in this virtual studio instead of the real studio showed no significant difference in performance when compared to prior classes. Brown & Cruickshank's (2003) results were an early proof of virtual instruction's educational efficacy. However, their program was displayed on a 2D computer monitor and therefore not immersive, whereas the VR program made for this project is immersive in 3D.

Elixxier is a German software company specializing in software for photographers. Their flagship program, set.a.light 3D, is a lighting simulator available on Windows and MacOS platforms. set.a.light 3D allows users to customize a studio photography environment from the lighting equipment, configuration, and placement, to the photorealistic model appearance and pose (Elixxier, n.d.). Additionally, users can set up cameras within the scene with alternate lenses and focal lengths in order to preview a shot taken. The set.a.light 3D program is very robust and allows for fine tuning of lighting, camera, model, and environment configurations with accurate shadow reproduction, making it a useful tool for studio photographers who want to preview a setup (Ovchar, 2021). For students learning studio lighting concepts for the first time, the program does not offer in-application guided instruction. Further, the program displays a 3D scene on a 2D computer monitor, not fully immersing the user in the environment.

The existing programs mentioned above have informed the current project's scope and direction. This project seeks to exceed the capabilities of Brown & Cruickshank's (2003) program, yet no attempt is made to be a full-fledged studio simulator as detailed as Elixxier's set.a.light 3D. DiVR 360 serves as an example of the target level of complexity and interactivity sought for this project.

Method

The PhotograVR application is an immersive and interactive educational VR application that teaches participants about basic photography lighting principles. The application is created in Unity for the Oculus Quest 2 and requires only the Quest 2 headset and a 16'x16' space free from obstacles.

To test the effects of social presence on the learning outcomes, two versions of the application exist: one with a human instructor and one with an abstract ethereal instructor. Both versions are identical in every way except that the socially present version features a woman for the instructor avatar while the other version features a floating glowing orb as the instructor.

Lesson plan/Script

Katie Hollister is responsible for the instruction outline and script for this program. For this proof-of-concept, the scope of instruction is limited to a single lesson on three-point lighting—a fundamental lighting principle widely employed in professional photography and videography. Three-point lighting is a key learning objective from GRC 301 (the reference course of this project). The scenario is written to require interaction throughout the lesson and take 5-10 minutes for a university-level student to complete. The 360º immersion of VR adds complexity to the script writing process, ultimately requiring step-by-step stage instructions mixed with lines of narration guide the flow of the experience.

Design

As a student pursing the discipline of user experience (UX) design and concentrating in Experience Design for Extended Realities (XDXR), I place emphasis on the design phase to consider the usability, accessibility, and ease of use of the program. As an emerging technology, VR has yet to be widely experienced by the general population; students who are learning through VR are unlikely to be familiar with the platform. To create an experience friendly to new VR users, iterations of the VR scene and interfaces are sketched with pencil and paper with use of Andrew Leitch's (2017) VR storyboard template. Oculus' recent release of hand tracking eliminates the need to hold VR controllers and allows for more natural interactions in the program.

Technology

The primary deliverable for this project is a VR program for the Oculus Quest 2. The Oculus Quest 2 is the target development device because of its widespread commercial availability, top-of-the-line processing power, and ability to run applications without being wired to a computer (Meta, n.d.). All development of the VR application is done in Unity version 2021.3.2f1 with Oculus Quest 2 interfacing enabled with the Oculus Integration SDK plugin. The completed application was exported as an .apk file and sideloaded with the free SideQuest software (SideQuest, n.d.) onto a Quest 2 device. The lighting equipment and human model assets are purchased from AT Studio and Humanoid Animations respectively from Turbosquid.com. Development of the application in its current state took place over four weeks in Spring quarter of the 2021-2022 academic year. All programming and application building was completed by me.

Pilot test/survey

Pilot testing is conducted with members of the project team to validate the application's efficacy. A pilot test session begins with starting the application and orienting the Quest 2 headset in particular direction to fit the boundaries of the physical space. A human/non-human instructor version is randomly selected, then, a participant secures the headset to their head and can immediately begin interacting with the environment within the application. The lesson does not begin until the participant presses an indicated virtual button in the application. After the lesson is complete, the participant removes the headset and completes a Google Forms post-survey comprising of five demographic and 19 experiential questions. Data from this post-survey includes both qualitative (short answer) and quantitative (1-5 Likert scale) data. After completing the post-survey, the participant is thanked for their time.

Results

Virtual reality application

The VR application created for this project was developed to test various human-computer interaction hypotheses such as the effects of social presence on learning in VR.

However, the development of the application was itself a practicum for the process of planning, designing, and developing a virtual reality application. The planning phase had outlined several requirements for the application, primarily participant movement throughout the scene, interactive lights (on/off, intensity up/down), guided instruction, and a virtual camera that outputted images for review. Of those primary requirements, all were implemented except for the virtual camera, which would allow both the participant and course instructor to check the student's understanding or completion of the lesson. Figures 1, 2, and 3 are screenshots from the participant's view in the application.

The application's core, the `StoryManager`, orchestrates the sequence of the script, holding the narration clips and the requirements to advance within the lesson. Based on a linearly progressing script, `StoryManager` sequences its children `StoryClip` objects which are comprised of smaller `StorySnippet` objects. `StorySnippet` objects are the baseline building block of the `StoryManager` and can contain an audio file (typically a narration voiceover), a text header, a text block body (typically the voiceover closed captioning), and any number of events to trigger (e.g., turning on or off lights automatically). See Figure 4 for a diagram of the `StoryManager` organization.

Pilot test

Two pilot tests were conducted outside of my own tests; my own testing feedback is ignored due to bias from developing the application. For both pilot tests, the post-survey was not completed. Instead, verbal feedback from the participants while progressing through the experiment was noted down and synthesized into Table 1 with frequency counters. The most apparent feedback is the frustration of not being able to advance through the lesson due to unresponsive inputs or a lack of clarity in the virtual environment controls. Secondly, the human instructor was interpreted as being a fellow student rather than the instructor, potentially due to their position out of the student's typical line of sight. Further, the abstract non-human instructor was not clearly identifiable as an instructor or anything significant. One pilot tester reported it as a glitch in the application due to its flat appearance instead of a glowing sentient "other". Still, the room-scale virtual environment is reported as appearing true-to-life which supports the participant's immersion. The script and verbal narration reads/speaks clearly and teaches the essentials of the intended concepts. Participants desired more interactive portions of the lesson since it is intended to be a repeatable lab rather than a lecture in 3D.

Discussion

The process of developing the current version of the PhotograVR application taught me about quirks of Unity, working with SDKs, and the development/testing cycle for an Oculus VR platform. Feedback from the pilot testing shows that there is room for improvement, as expected from a proof-of-concept, but does fulfill most of the initial requirements.

There are clear areas for the application to improve before moving on from the pilot testing stage and conducting official experiment tests. First, the interactions required to advance through the lesson are not clear or responsive; a participant who is inhibited from completing the lesson is unlikely to learn effectively. Second, the instructors need to be more clearly defined and command a presence. Future design analysis and informal tests should compare controller-based inputs versus hand gesture inputs with regards to inexperienced VR users and placement or animation of the instructor avatars to strengthen their presence and authority. A significant and unexpected disruption in the development schedule which prevented the virtual camera to be incomplete was the quality of Oculus' SDK components. The kit, which is supplied directly by the Oculus Quest 2 developers contained key components which were not updated for the latest versions of Unity or supplied with adequate documentation. The `StoryManager` designed for this scenario is adequate for a linear script but would likely need to be modified for a non-linear or dynamic lesson script. Accessibility can be improved as the current version requires a large, open physical space to match the in-application space.

Conclusion

As a proof-of-concept for interactive visual arts education in virtual reality, the PhotograVR application in its current state shows potential for adequate educational efficacy and flexibility of use. A stable and effective baseline application requires a significant amount of time from a particular programming skillset to develop. But once complete, it can host numerous immersive and interactive VR lessons that use the same virtual environment. Three-point lighting is just one of countless photography and videography principles that visual artists across the globe learn. The benefit of VR education is not just the immersion or interactivity, but also the accessibility and flexibility to learn the content at any time or place as if the learner is actively participating in a classroom. PhotograVR will continue to be refined as an educational medium and research tool into the 2022–2023 academic year with funding from the Cal Poly Center for Expressive Technologies Seed Grant.

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Tables

Table 1

Pilot testing feedback

Feedback	Sentiment	Frequency of mention
Interactive controls unclear	Negative	2
Unclear next steps after task complete	Negative	2
Irrelevant controls distract from objective	Negative	2
Instructor does not appear legitimate	Negative	2
Environment is true-to-life	Positive	2
Portion of lesson not engaging	Negative	1
Test setup is clunky	Negative	1
Narration is smooth	Positive	1

Note: Pilot testing was conducted with two individuals on the project team. *Frequency of mention* is limited to 1 count per participant.

Figures

Figure 1. The human instructor in the PhotograVR application.

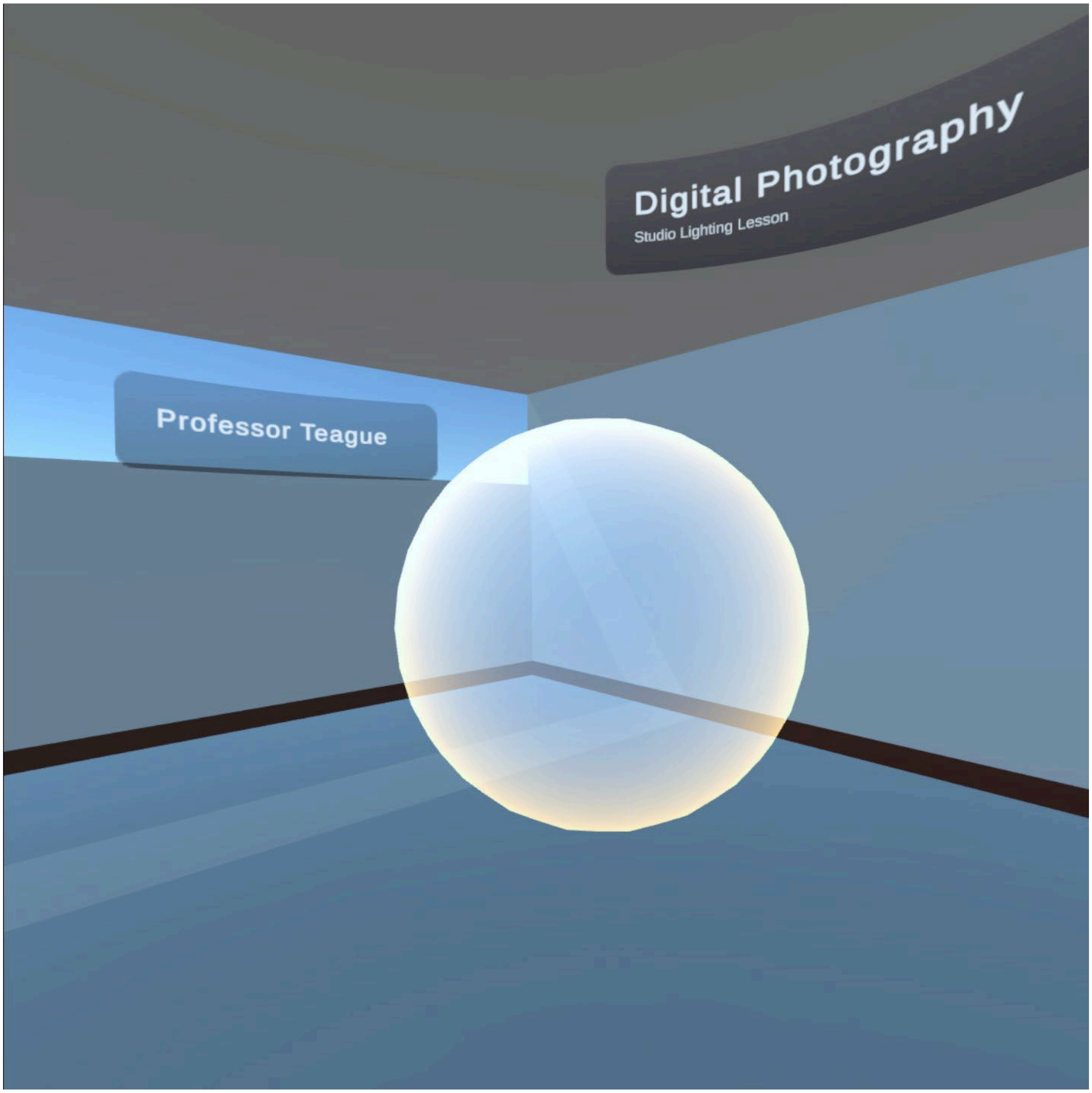

Figure 2. The abstract instructor in the PhotograVR application.

Figure 3. The studio scene in the PhotograVR application. Both the human and non-human instructor scenarios feature the same studio setup and lesson.

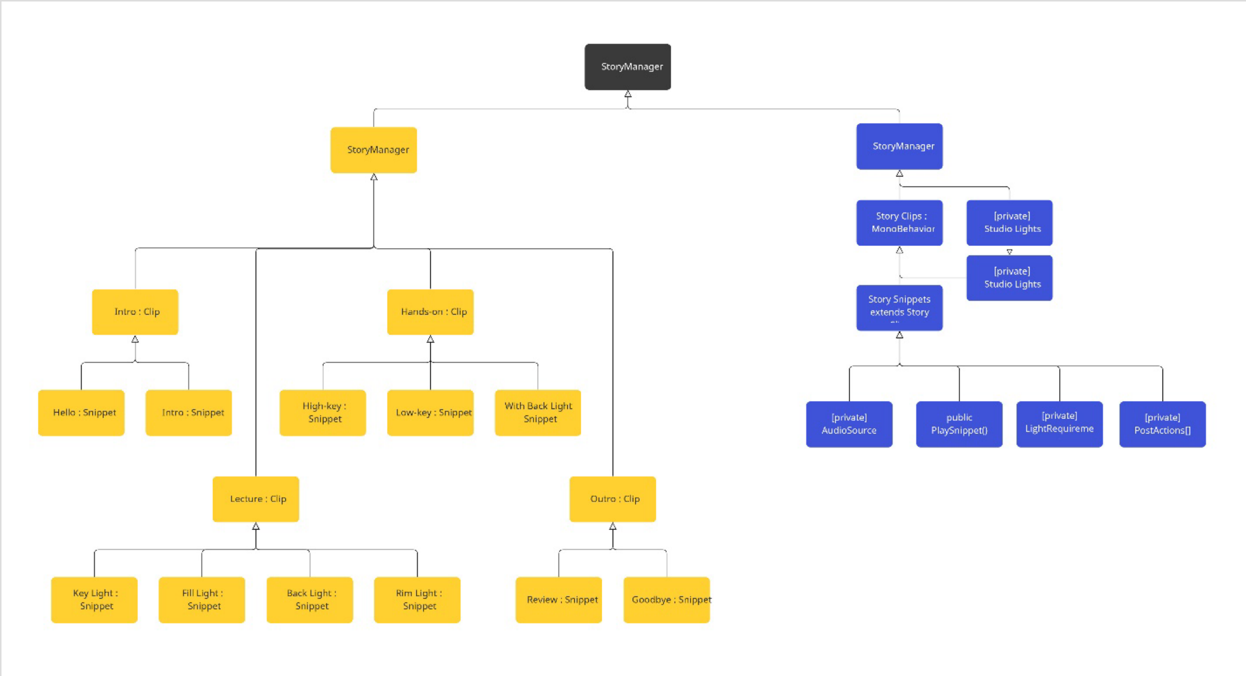

Figure 4. Structure of the `StoryManager` component in the PhotograVR application.