Student Interaction and Collaboration in Virtual Reality

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Abstract

In many on-campus classes, collaborative projects engage students in shared creative experiences. Verbal and nonverbal interactions within the classroom provide lessons in group decision-making, brainstorming, teamwork, and leadership. This type of interaction is more challenging for students taking online classes. Virtual Reality (VR) can potentially be an alternative to this type of physical interaction. This white paper reports a preliminary study with undergraduate students who participated in collaborative projects in two VR applications, *Spatial* and *The Wild*. Challenges in implementing VR into online courses are discussed, followed by important considerations for the future use of VR in online courses. Finally, we discuss the implementation of VR using the Technology Acceptance Model, a framework delineating the conditions in which users will adopt, use, and become competent in new technologies.

Introduction

Communication and collaboration are essential skills across all sectors of society. In higher education, interaction among students is an important principle of the collaborative approach to learning. Through collaborative learning, students report greater satisfaction with the process of learning and demonstrate improvement in learning outcomes (Benbunan-Fich, 1997, as cited in Ocker and Yaverbaum, 1999). The team-based model has been successful in terms of reported student experience and resulting projects, but it has primarily been available to students taking on-campus classes. Students will benefit if the team-based model can be introduced to online courses. However, there will need to be a viable alternative to synchronous in-person interaction that can approximate the same sense of presence and engagement in a collaborative online learning environment. Virtual Reality (VR) has the potential to address this need for fully distanced students. Virtual world interaction allows for increased interactivity due to the combination of synchronous communication and spatial orientation (Petrakou, 2010). There have been many studies demonstrating the efficacy of VR as a tool for collaboration (see Pidel & Ackermann, 2020 for a review); however, there is limited research-based evidence that it can be used as a successful alternative to collaborative work in *online* educational settings.

Our research was intended to further explore VR's potential to facilitate collaboration with an emphasis on collaborative story development and group interaction in 3D spaces. However, due to our small sample size, the results of this study are limited. In this white paper, we share the design of our research project and highlight some preliminary findings from participants' experiences in VR. The main focus of this white paper is to share the lessons we learned as a function of conducting this research. We conclude with a set of considerations required for the successful use of VR in educational settings.

Method

Study Purpose

The purpose of the study was to document student interaction and collaboration in virtual reality by having small groups of students meet in VR to work together on creative activities. These included brainstorming and story development activities as well as modification and evaluation of 3D environments. We specifically examined student participation, collaboration, and creativity.

Courses in the Study

We conducted the study in a mixed modality (hybrid) version of NMC 351: New Media Visualization course at Oregon State University (OSU). The study was also designed for an online version of this course. The course introduces students to VR applications using Quest VR headsets. Because the principal investigator (PI) Kesterson was also the course instructor, he was not involved in any communication with the study participants aside from ordinary class instruction. The co-PI Loges contacted the students to confirm participation. Research assistant Todd organized meetings and conducted the group activities.

VR Hardware and Software

We used Oculus (now Meta) Quest and Quest 2 VR headsets that are wireless and do not require a personal computer to operate. We selected the VR apps *Spatial* and *The Wild* for this study. *Spatial* is free and allows for collaboration via virtual sticky notes and white boards, among other tools. *The Wild* is a subscription service tool designed for architecture engineering and construction (AEC) teams. We selected it for its 3D model manipulation capabilities.

Study Preparation and Participant Recruitment

At the start of the 10-week mixed-modality course, students were required to check out a Quest or Quest 2 VR headset from the OSU library for the duration of the term. Tutorials on setup and operation of the Quest headsets were provided online. The class was assigned videos to review that provided overviews of the VR apps *Spatial* and *The Wild*. Students were informed that these apps would be used in the research study. Prior to the introduction of the study, students were also required to review apps on the headset that they had checked-out. Completing these reviews demonstrated basic proficiency in using the Quest headset. In week four of the 10-week academic term, the PI introduced students in the class to the research study and invited them to participate. Participation was voluntary and had no impact on course assignments or grades. Interested students were directed to take a Qualtrics survey that included the consent and parental permission/assent forms for students under 18. Those forms included health and safety warnings and other pertinent information, including the recording of VR sessions for research purposes.

The study was designed to fit within an existing course (NMC 351: New Media Visualization) with a cap of 25 students per term. Over the duration of the study this would have resulted in a maximum of 75 eligible participants. However, we were only able to recruit enough students to run the study once with one group of four students in Fall 2021. We had one or two interested students in each of the following two terms, but that did not meet our minimum requirement of four participants. To ensure that synchronous online meetings would not be required of students in the fully online NMC 351 course, this study was run independently of the class. No demographic information was collected on the four students who participated.

VR Activities Schedule

Three online meetings included a brief Zoom introduction followed by sessions in virtual space. The first meeting took place in week six and lasted 45 minutes. The research assistant gave an introduction to the study via Zoom, followed by a hands-on introduction to the VR app *Spatial*. Participants also installed *The Wild* app in preparation for future meetings.

The second meeting occurred during week seven. It began with brief Zoom meeting and an introduction to activities within *Spatial* that lasted a total of 25 minutes. This was followed by two 30-minute activities separated by a five-minute break. The session concluded with hands-on training in *The Wild* app.

The third meeting occurred during week nine. This meeting included a 15-minute Zoom introduction to activities in *The Wild* and 25 minutes for each of two activities in that app, separated by a five-minute break. We video screen-captured student interactions in the VR apps in all sessions.

VR collaborative activities conducted during meeting 2 in Spatial.

1. ***Drawing.*** In the VR app *Spatial*, each student was given a collection of virtual sticky notes of a certain color. Each sticky note featured curves or simple shapes. Students took turns creating an image by adding a sticky note(s) to the evolving image. This was open-ended drawing; there was no “correct” outcome.
2. ***Group Brainstorming.*** In another *Spatial* activity, students chose someone from their group to be a scribe for a group activity. Their task was to write notes on a virtual whiteboard during a group story brainstorming activity. The other participants were tasked with developing

backstories for characters and their environments and then developing a story that would bring the characters together for an encounter. The group discussed how the story could be improved from a narrative standpoint.

VR collaborative activities conducted during meeting 3 in The Wild.

1. ***Rebuild and modify.*** For the first activity in *The Wild*, each participant was given a selection of virtual objects from a dismantled room in addition to objects not part of the original structure. The objective was for participants to reassemble the virtual room as they imagined it was originally constructed. Additionally, participants were asked to place the other objects that were not part of the original room space. This allowed for creative variation on the original.
2. ***What's wrong with this space?*** For the second activity in *The Wild*, a virtual space was constructed of improperly scaled objects, textures, or structural elements (e.g., doorways) in relation to human scale. Participants were instructed to put virtual sticky notes on the objects indicating what was wrong with each and how it could be fixed (e.g., the doorway could be widened). This was intended to help students understand the importance of scale and spatial navigation. Following the activity, while still in VR, the students discussed their observations with each other.

Avatar Representation and Participant Confidentiality

To protect participants' privacy and confidentiality in the recorded VR sessions, in *The Wild*, participants' avatars looked identical except for color variation. In Spatial, color variation was optional. (In our study, several students selected the same color.) Students were required to choose a fictitious screen name, but real names were not visible (see Figures 1 and 2). Prior to transcribing the dialogue, the research assistant removed any unique identifiers, such as names, from the audio track of the video recording.

Figure 1. *Avatars in Spatial*

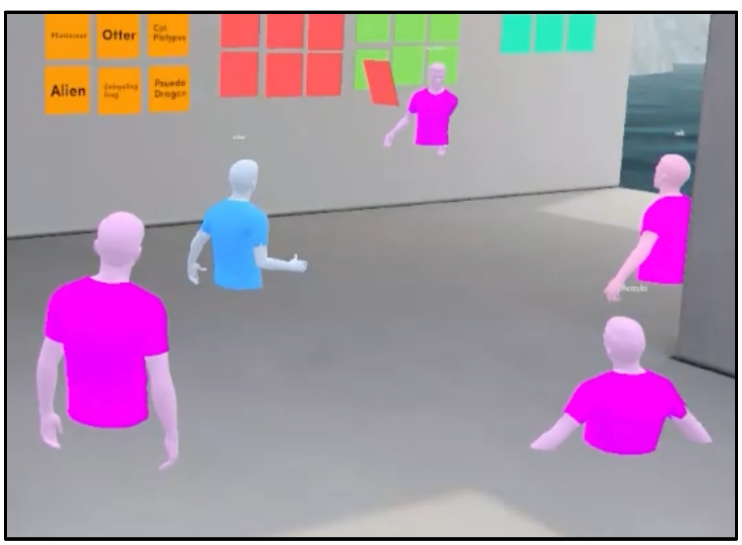

Figure 2. *Avatars in The Wild*

Follow-up Interviews

After the course concluded, Co-PI Loges conducted semi-structured interviews (Hammer and Wildavsky, 1993) with participants via Zoom. These lasted between 23 minutes and 1 hour, 15 minutes. Interview questions focused on student experience in terms of participation, collaboration, and creativity in VR. For the participation category, we asked the following five questions.

1. Tell me about how you were able to participate in this class through the technology.
2. Can you describe occasions when you were particularly pleased with the way you were able to participate?
3. Can you describe occasions when you were particularly unhappy with the way you were able to participate?
4. Can you compare the difference between participation through *Spatial* and participation through *The Wild*?
5. Can you describe how your participation in this class compares with your participation in other classes you've taken?

Follow-up questions were asked to clarify what software applications the students were referring to in each response, and whether or not team communication was a problem.

Preliminary Results

Overall, students expressed enthusiasm for the process of collaboration and creativity in VR. However, in numerous responses students expressed limitations of VR tools in terms of ease of use and comfort. Timing and the limited flexibility in some of the activities were the most common areas of dissatisfaction.

Appendix A provides examples of interview responses from the four participating students organized into general categories that were created based on a review of their larger collection of responses.

Considerations for Adoption of VR in the Classroom

Based on the research we conducted, the potential for VR in online education remains promising. As indicated by our participants, VR can introduce students to engaging, immersive activities that can foster a sense of presence required for creative collaboration. These types of activities may seem valuable; however, there are also many factors to be considered before making the decision to include VR headsets and apps into the classroom or an online learning experience. In conducting this research, we learned a great deal about the challenges of incorporating VR headsets into a university class. These lessons have relevance to other educators considering adopting VR technology into their curriculum. We describe these considerations based on our experience preparing for this research with students in an online course.

IRB: Reviewing VR Technology

Based on our experience, institutional review boards (IRB) may have many concerns related to the health and safety of minors (i.e., students under the age of 18). The likelihood of having minors in a college class is low and removing that population from the study can eliminate that concern.

Although consumer-level VR headsets, including the Oculus Rift and HTC Vive were both introduced in 2016 VR technology might still be unfamiliar to some IRBs. In our experience, concerns were related to basic health and safety issues explained in the Quest headset documentation. In future research, a reference to those documents may be sufficient. Data privacy was another concern. At the time of this study, the Quest 2 headsets required a Facebook login, which posed potential risks to participants' privacy. This concern was addressed by providing participants an option of using a Quest 1, which allowed for an anonymous Oculus account login. Note that in Fall 2022, Meta shifted its login approach so that a Facebook account is no longer required on Quest headsets; a new Meta account is required instead.

Budgetary and Technical Considerations for an Online VR Course

This study was designed to be conducted in an online class (NMC 351) of 25 students. We required enough Quest and Quest 2 headsets for each student in the class to check one out for the entire term. This is essential for an online class that makes use of VR headsets throughout the term. Students in online classes don't have access to campus to check headsets in and out each week.

For NMC 351, the New Media Communications program and OSU Ecampus purchased 60 Quest headsets. This number included enough backup devices to account for loss or damage, as well as headsets for Ecampus instructional designers and Disability Access Service employees as course content was developed. Managing this large number of headsets poses many challenges for anyone considering such an investment. There must be an organization that manages the equipment. OSU's Valley Library provided this service for NMC 351. Every component of the headset was barcoded and tracked. Headsets were mailed to students with return boxes and postage included. This is a complex operation that takes significant time at the start and end of every term. Equipment maintenance between terms involves cleaning and charging the headsets, replacing controller batteries, updating software, and determining if the equipment has been damaged. In such cases, it is generally much faster and potentially less expensive to replace a headset than to send it for repair.

Another key factor is obsolescence. When OSU transitioned to remote teaching during COVID-19 in Spring of 2020, the New Media Communications program ran a lab with Oculus Rifts and HTC Vives connected to desktop PCs. Students in the on-campus version of NMC 351 were required to visit the lab each week to explore assigned apps. By the time we returned to campus in Fall of 2021, those headsets were obsolete. They had been replaced by the Quests, which did not require cables or PCs to run (though they can be connected to PCs to run some computationally intensive apps). As headsets become lighter and more powerful, the current Quest 2s will also become obsolete. They will still be usable for some classes but will not be sufficient for a class like NMC 351 that is designed to provide hands-on experience with current X-reality hardware.

Budgeting should include planning for devices to be replaced every 3-4 years. Because of the need for one headset per student per term in an online class, headsets can only be used in one class each term. Purchasing these headsets is a significant investment. As of August 2022, the basic Quest 2 headset cost was $399 (reflecting a recent price increase). Including a $30 case, a suite of 30 Quest 2s (accommodating a class of 25 students with 5 backups) results in a total cost of $12,870. Planning for a replacement cycle of 4 years (one year beyond optimal), the pro-rated cost is over $3,200 per year. This cost does not include funds for VR apps. Many apps are free, but others may cost between $10-30 per app for each device. Shipping costs are another consideration for online classes. For NMC 351, the cost of mailing the VR equipment via FedEx, including insurance and return packaging, was approximately $50 per unit, adding another $1,250 per term to be covered through course fees for a class of 25 students. Note that these estimates do not cover the cost of service and support personnel, which is a significant ongoing cost that is sometimes overlooked or underestimated when purchasing decisions are made. Without dedicated funding, the burden of support and maintenance may fall on already over-extended support units.

Inclusion and Accessibility for Students Working Remotely in VR

In NMC 351, students review VR apps independently. Those unable to use the apps due to vision limitations, medical conditions, issues with nausea, or hardware problems can watch video walkthroughs of the apps. This is not an equivalent experience, but it is a way for students enrolled in a required class to at least be exposed to VR content. In a class requiring student participation in VR group activities, the alternative to being in VR would be participating in group work via a

PC or mobile device. This raises the issue of inclusion. Participating in some shared VR experiences (e.g., 3D modeling) from a PC without a headset is not an equivalent experience to that of students experiencing the world from within VR where they can directly manipulate objects using both hands and VR controllers.

Internet connection. Another issue related to inclusion is internet speed. Many educators have dealt with this to some degree during remote synchronous classes taught via Zoom during the COVID-19 pandemic. Many students and faculty had latency issues or were unable to access the online classes due to internet speed or connectivity problems. Remote VR requires high speed, reliable internet connectivity, and for many students, this is not available due to financial constraints or location.

Physical space. Another important consideration for VR is physical space. Meta (formerly Facebook) recommends a minimum unobstructed space of 6.5 feet by 6.5 feet (2 meters by 2 meters).[1] Many people do not have such an unobstructed space. While it is possible to use a headset in a standing or sitting mode for some VR apps, other VR experiences, such as Beat Saber, require sufficient space for full body motion.

Health and Safety Considerations Related to Activity Planning

Meta recommends users limit their time to 30 minutes and take breaks[2]. When working independently, students can easily follow that guidance. We accommodated this in our study, which required careful planning for our activities. This time limit would likely be more challenging in a full class of students in which you need to account for login time and group management once in the virtual classroom. A class lasting 50 minutes would likely include an initial five-minute login time, a maximum of two 18-minute VR sessions, a five-minute break between sessions, a two-minute re-login time and a two-minute wrap up, allowing students to log out and put away their headsets before the next class. This does not include time for activity introductions within the apps, or any technical problems that prevent students from logging in or participating in the virtual experiences.

Hardware and Software Reliability

Based on personal observations and experiences over several years, VR hardware and software are not sufficiently reliable to depend on for remote, real-time student interaction in virtual space. Anyone who works with technology has likely experienced challenges with software and hardware crashes. Standalone VR headsets are mini-PCs that can experience overheating and potential physical damage from dropping or collisions. Hand controllers are also relatively fragile. Students sometimes return headsets damaged, and those issues may not be discovered until the following term by a different student. Software updates are often automatic, which can lead to unanticipated glitches. These are challenging issues even under an optimal scenario with immediate hardware support. Providing such support is a formidable task for any institution given the specialized nature of the equipment. Students working alone with no troubleshooting support often have difficulty overcoming these obstacles.

These technical challenges exist even in very well-funded location-based collaborative VR settings. There may be a day where this is not the case, but VR technology is too unreliable to be depended on for scheduled group interaction, particularly with students working independently (i.e., no technical support) and remotely.

Conclusion

According to the Technology Acceptance Model (see Wingo et al., 2017) *perceived usefulness* is key to faculty

[1] https://www.meta.com/help/quest/articles/getting-started/getting-started-with-quest-2/space-to-use-quest-2/

[2] https://www.meta.com/legal/quest/health-and-safety-warnings/

adoption of any technology. Decades of research into the diffusion of innovations identifies perceptions of *relative advantage*, *compatibility*, *complexity*, *trialability*, and *observability* as crucial factors weighed by individuals when considering adopting an innovation (Rogers, 2003). For now, many of those factors do not favor adoption of available VR hardware and software in educational settings. VR promotional materials and successful use case scenarios support the idea that VR is useful in the classroom. This needs critical evaluation, as the actual benefits vary based on the specific usage. *Perceived ease of use* is also an important consideration in the decision to adopt technology; the challenges and barriers described here, such as perceived difficulties managing a classroom of VR headsets, factor into these perceptions. There are many factors to consider before making the investment in this evolving technology. Without careful research and preparation, VR can be a costly, frustrating, and ultimately an unsuccessful addition to any classroom. Educators must have a realistic perspective on the challenges involved in bringing VR technology in the classroom or an online course prior to making any decision.

One approach to help educators evaluate VR in a controlled setting is to provide dedicated campus VR labs. The New Media Communications program has operated a VR lab for several years. Prior to the Quest headset checkout program described in this paper, students were required to visit the lab each week to experience VR apps. Student lab assistants were responsible for equipment setup, basic maintenance and app installation. They helped students and faculty learn how to use the headsets and to navigate the software, and they coordinated with campus computing support for any major hardware issues.

This is a similar model to how some advanced campus computer labs are run. The common attributes are a dedicated university space with funded technology support and an ongoing budget for upgrades and maintenance. This model frees educators, individual departments, and support units from incurring the costs and workload associated with startup VR programs. It also provides a controlled environment to support further research on the use of these evolving technologies in education.

This lab model does not directly address the challenges associated with remote deployment of VR headsets for online courses. It does point to the importance of a centralized system of support and maintenance necessary for the successful integration of VR technology for any educational setting. This is an essential starting point for evaluation, and one that would provide educators with the information and experience necessary to make informed decisions about the use of VR technology in their curricula, regardless of the modality.

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Appendix A

Participant Responses to Interview Questions by Category

VR Tools Limitations and Benefits
"I think it's still too early for both technologies, that they need a lot more sophistication in order to actually be helpful in your everyday tasks and communicating with other people, working together with other people. I think for now it's a fun little activity, but I don't know if it would actually be that productive."
[Lack of precision with drawing tools] "makes the process of drafting ideas and editing drafts in a group feel a bit just better, because I'm not worried about making something look good, because it is impossible to make something look good. So all I need to worry about is getting my point across."
Physical and Emotional Comfort and Discomfort
"with *The Wild*… the room was pretty big, and we could teleport to the top, and… I have a bit of a fear of heights, so I couldn't go all the way to the top"
"I have very severe social anxiety. And so being in person, I get incredibly anxious, and often times I kind of just shut down and I stopped being able to really… … And it really dulls my ability to participate in collaborative projects in-person… but in the *Spatial* and in *The Wild*, you have the partial anonymity of not being like physical people. You're avatars, which means people know who you are, but… you're not actually like there. … I feel like I gained an incredible amount of comfort"
Participation, Collaboration & Creativity in VR Compared to In-person
"…collaborating in virtual space, in either the *Spatial* or *The Wild*, was… incomparably better than the current Ecampus system that I've found at pretty much any college I've been to. … Ecampus really is just glorified book reading, with YouTube videos attached to it."
"Being creative collaboratively is… astronomically better than anything Ecampus is able to provide. There's just… even with, like, three or four person groups in Zoom, there's such a disconnect. It's really hard to remain present and be creative and make progress in a project. And I feel *Spatial* really breaks that disconnect, and allows us to feel more comfortable and more present and be able to iterate on concepts and generate concepts a lot easier…"
Study Design
"…in *The Wild*… I probably could have sat there for, like, hours and just made shapes and weird stuff. Yeah, but obviously we didn't have time for that."
One student felt there was "limited time to bounce ideas back and forth."

About the Research Unit at Oregon State Ecampus

Vision

The Ecampus Research Unit strives to be leaders in the field of online higher education research through contributing new knowledge to the field, advancing research literacy, building researcher communities and guiding national conversations around actionable research in online teaching and learning.

Mission

The Ecampus Research Unit responds to and forecasts the needs and challenges of the online education field through conducting original research; fostering strategic collaborations; and creating evidence-based resources and tools that contribute to effective online teaching, learning and program administration.

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