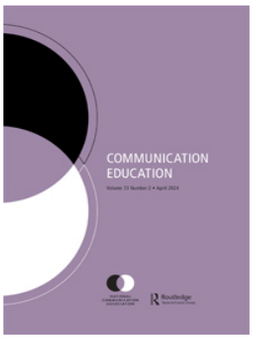

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ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rced20

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To cite this article: Eugy Han & Jeremy N. Bailenson (2024) Lessons for/in virtual classrooms: designing a model for classrooms inside virtual reality, Communication Education, 73:2, 234-243, DOI: 10.1080/03634523.2024.2312879

To link to this article: https://doi.org/10.1080/03634523.2024.2312879

Published online: 20 Mar 2024.

COMMUNICATION EDUCATION
2024, VOL. 73, NO. 2, 234–243
https://doi.org/10.1080/03634523.2024.2312879

NATIONAL COMMUNICATION ASSOCIATION
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DISCUSSION

Lessons for/in virtual classrooms: designing a model for classrooms inside virtual reality

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Introduction

From working to socializing to learning, many of our daily routines can be accomplished virtually and have increasingly been done so. In the United States alone, the number of people working remotely jumped from 8% to 26% between 2019 and 2022 (Statista, 2023). Similarly, the number of higher education students who enrolled in distance education courses jumped from 36.3% to 59% between 2019 and 2021 (2022 National Center for Education Statistics). Although virtualization has had its share of advantages, it has also introduced unanticipated challenges. As workplaces and classrooms explore ways to migrate their practices successfully online, these successes and challenges must be characterized to inform future iterations of workplace and classroom interactions.

The course *Virtual People* is a forerunner in this field, as it experimented with a novel form of virtualization. Housed in the Department of Communication at Stanford University since 2003, the course traditionally took place in large lecture halls, with the professor lecturing in front of hundreds of students. In summer 2021, the course transitioned to a virtual format. Unlike most remote courses that migrated to the 2D virtual space, *Virtual People* moved into immersive VR—virtual worlds that shut out the outside world and immerse the user in the surrounding environment. Instead of receiving Zoom links, students were sent Meta Quest 2 headsets, which they used to meet in a virtual classroom (Figure 1).

In addition to other activities both inside and outside of VR, during the 10-week course, every week for half an hour, students met in small groups with a teaching assistant to discuss that week's course content, draw in 3D space, build with models, and write on whiteboards. Soon, students turned into 3D avatars, and the classroom turned into serene Greek courtyards surrounded by nature or stadium-sized swimming pools. In these virtual classrooms, students could not only see spatialized representations of themselves and each other (i.e., maintain consistent body orientation and personal space) but also travel to various locations that would otherwise be difficult or impossible to get to.

Such affordances are what have made VR a viable tool to support learning (Mikropoulos & Bellou, 2010). Virtual reality has been attractive for educators, given their immersive and interactive nature. Researchers have examined learning in devices such as head-mounted displays (HMDs) or cave automatic virtual environments (see Wu et al., 2020, for a review). Research shows that, in comparison with low immersion media such as

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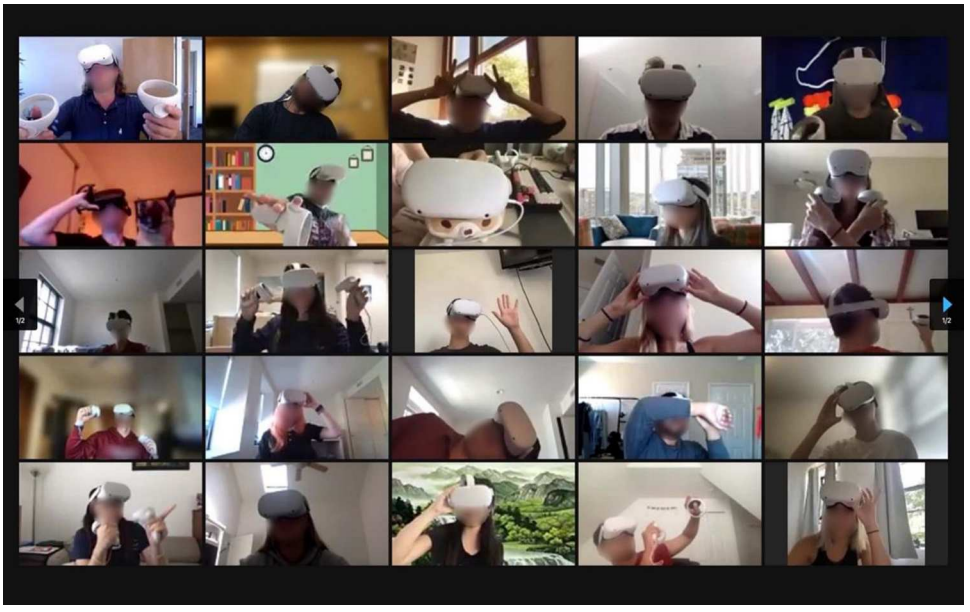


Figure 1. Students wearing Meta Quest 2 headsets to join the VR classroom from various remote locations.

video or text, VR-based learning resulted in greater presence, enjoyment, motivation, and transfer—the ability to apply acquired knowledge in a different context (Makransky, Borre-Gude, et al., 2019; Meyer et al., 2019; Petersen et al., 2020). At the same time, immersive VR has been shown to increase cognitive load (Ahn et al., 2022; Makransky, Terkildsen, et al., 2019; Whitelock et al., 2000), and users can feel nauseous from simulator sickness after a few minutes. Given the multisensory nature of IVR, the essential cognitive processing that goes into synthesizing the media content may exceed students' cognitive capacity (Mayer & Pilegard, 2005). Consequently, despite the attractive educational outcomes of IVR, from an application standpoint, how the technology is incorporated into the classroom and the curriculum is critical (Makransky et al., 2021; Petersen et al., 2020).

In recent years, this interest in using IVR for learning and teaching has been growing. As HMDs become increasingly accessible, we can anticipate seeing them being integrated into classrooms and curricula similar to how other media computers have been. However, the idea of bringing students into VR may be daunting, for both the students and the instructors, and especially so for those who would be trying VR for the first time. Despite the growing popularity of HMDs in contexts outside of gaming and research, VR remains a novel tool for many. Stepping back from the learning aspect of a classroom, there are components before, during, and after that contribute to the experience. Ultimately, a collaboration between the instructors and students will have to take place for the benefits of VR to be reaped within a classroom context.

The challenges faced by students and instructors are likely different. Across three iterations of *Virtual People*, a summer session course *Into the Metaverse*, and a pilot class at the University of Connecticut, as well as across multiple roles as student, teaching

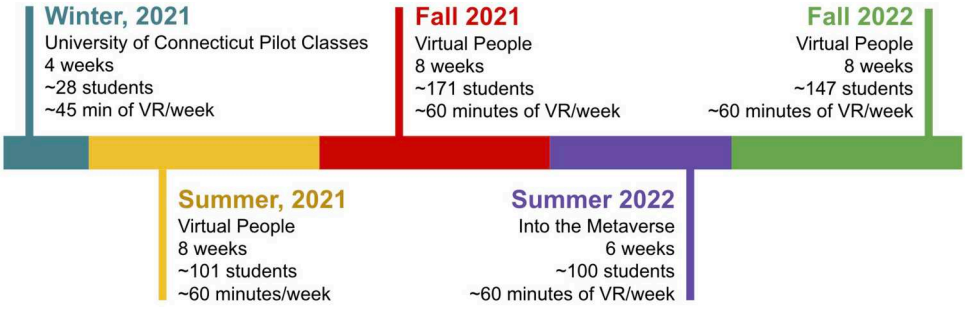


Figure 2. Timeline of courses that we offered that were taught inside immersive VR.

assistant, and instructor, we have been able to identify themes that have emerged (see Figure 2). In the following, we describe the pedagogical challenges we have faced, both expected and unexpected, from the perspective of the teaching staff (~540 people across five courses). We also offer recommendations for how to build VR into appropriate educational contexts in sustainable, equitable ways.

Learning VR before learning in VR

The concept of finding your way *inside* a virtual world, or even knowing what it means to simply exist within it, may be challenging to grasp if one is unfamiliar with the landscape of VR. Students often display anxiety about getting into VR and are intimidated by the steps needed to do it for class, such as setting up the guardian boundary of the physical space, pairing the various hardware pieces (e.g., hand controllers) to appropriate software, and figuring out how to find and get to the virtual environment the class is being hosted in. Even before any learning within VR can take place, it may be useful to have onboarding training for students and instructors to ensure that they understand what VR is and what virtual environments are.

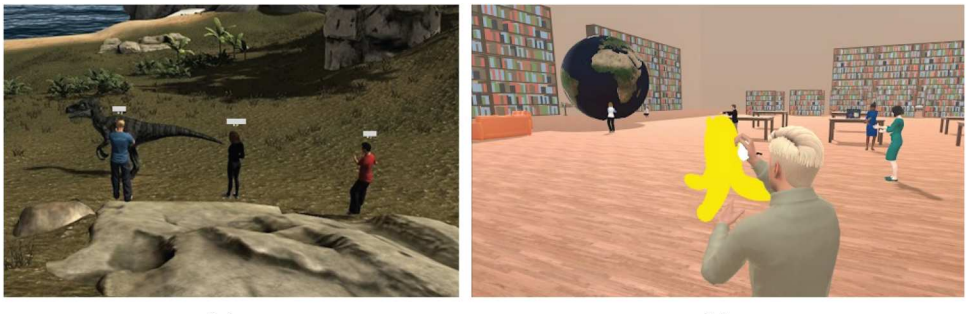
The most important idea to throw away is the assumption that being technologically savvy on internet search or TikTok transfers immediately to VR. Many instructors expect students to automatically be capable of VR instruction because they are a so-called digital generation. However, we have found that this technology is novel to almost all students and teachers, and requires training to realize its full potential. Through multiple iterations, we modified our onboarding processes based on the challenges students faced in the earlier offerings of the course. For example, we set up a discussion channel for students to help one another if they were running into similar issues and organized dedicated office hours for those who needed additional help. This allowed for students with varying levels of experience to set up the hardware at their own pace and seek support, if needed. Another example, we had a Zoom walkthrough for some of the more challenging VR tools, such as using the Cloud to access content saved on the headset or saving a VR recording. This allowed for students to focus on learning how to use the tools and take notes before jumping directly into VR. We additionally had a Zoom technical support call open during all our synchronous in-VR sessions for students to hop onto. This provided another avenue for students to feel comfortable if they ever felt lost or needed immediate help.

From these different iterations of the onboarding process, we concluded that it is important to not only have sufficient training of how to navigate the virtual space as an avatar (e.g., using the controllers to move and use the tools of a given platform) and technical support but also provide some introduction—even a very brief one—to what students can expect will help reduce initial hurdles of moving the class into VR. In our very first pilot course of 19 students in VR across 4 weeks (see Figure 2), what we found was strikingly clear: students need to learn *how to* use VR in order to learn *in* VR (Han et al., 2022). This foundation and toolset for how to use VR before even stepping into a virtual world is critical, and something the instructors should account for.

Much like how many courses have prerequisites or require some level of knowledge relevant to the topic (e.g., programming language in a coding class, or a mathematical concept in a statistics class), VR-based courses may move in that direction. Aside from logistical considerations, such as availability of technical support, size of the course, and duration of the course, what kind of knowledge is expected from students prior to the course and what kind of help will be made available throughout would largely depend on the course's end goals, its reliance on using VR, and the type of VR software(s) used. In the case of *Virtual People*, we did not have any prerequisites, and the majority of our students were from nontechnical majors, as our main goals were to provide students with hands-on experience with VR and to use VR as a tool for social connection. Consequently, providing one or two training sessions and having synchronous and asynchronous support channels were sufficient.

Finding the right material and tasks

The allure of VR may make it tempting for instructors to actively seek reasons to lead their students into VR. It is, after all, an exciting tool that many might be eager to try. There is certainly a plethora of games, experiences, and worlds offered in application stores that are worth trying. Although many of these software products can serve educational purposes, it is difficult to find *great* content that may fit educational needs (see Radianti et al., 2020 and Mado et al., 2022 for reviews). Moreover, current available content may not necessarily align with an instructor's specific needs, making



(a) (b)

Figure 3. (a) Students interacting with premade educational content available on ENGAGE. (b) Students using tools such as a 3D pen and models to answer educational prompts provided by instructors.

it challenging for instructors to find course-relevant VR experiences or applications (Figure 3).

Our courses were heavily centered on promoting social interaction and learning by doing inside VR. We used a social VR platform called ENGAGE to host weekly discussions. We also organized what we call "VR Journeys," which are experiences that are tied to the course material but can be done asynchronously. For example, when learning about VR as a tool for empathy, students tried out experiences such as *1000 Cut Journey* (Cogburn et al., 2018) and *Traveling While Black* (Williams, 2019). Or when covering the medical use cases of VR, we asked students to take part in a meditation session in AltspaceVR. In this vein, planning for what students can do inside VR may be challenging. Depending on the goals of the course, it would be important to be cognizant of how VR could be sustainably integrated into the class. Otherwise, VR could diminish into a dull toy that will eventually lose its shine. It is critical that instructors be intentional and informed about the type of material they will use and how it can be implemented or be enhanced using VR. Without careful and deliberate planning of what needs to be done inside VR and how those activities align with course goals, the headset may become an irrelevant tool that collects dust on the shelf.

Expecting the unexpected: challenging technical issues

Although VR has existed for decades, it is constantly being improved on. Although we fortunately do not have to wear the uncomfortable and heavy headsets of the early 1990s, current commercial headsets can pose human factors issues that do not have easy solutions. Similarly, VR content and worlds are constantly evolving and have yet to be developed.

In the past 2 years, we have run into a myriad of unique hardware and software issues. Some of them had straightforward fixes, such as doing a factory reset of the headset. Some required a bit more creative thinking, changing physical locations to find a different firewall that is compatible with the software. Others were gnarlier, and neither forums on the internet nor support teams of a platform or headset could figure out what was going on (e.g., unresponsive controllers, failed device pairing). In all cases, there was a need for collaboration from both the instructors and students to troubleshoot together.

As for software, content is continuously being modified and updated. Throughout the years, the social VR platform we used for most of our classes, ENGAGE, underwent several software updates. Occasionally, these software updates overlapped with our scheduled class times, resulting in students reporting issues that came along with these updates. For example, when the ENGAGE server went down for a few hours, everyone was locked out of the platform. Another example was, an update disabled the virtual keyboard for several students, rendering them unable to move past the log-in screen. Such scenarios required the instructors to think on the spot to come up with a new agenda. Other updates may occur on a larger timescale: software may disappear entirely. Content and platforms may stop being updated or deleted altogether by their developers, making them inaccessible in the near future. Such is the case for AltspaceVR, which went defunct in March 2023. In future iterations of our courses, we will no longer be able to use AltspaceVR and take students on a meditation journey to outer space. These gaps would need to be filled by a similar platform or an entirely different learning material.

Instructors would need to test and ensure that these content and platforms still function properly—or even exist—prior to adding them to their curriculum.

As much as this collaboration, improvisation, and development can be rewarding, it may also be quite mentally and physically taxing. We had a team of teaching assistants that took on different roles in the course. The troubleshooter is a significant role, one that will demand a great deal of time, cognitive effort, and physical labor. Virtual reality trouble-shooting may be a new and daunting territory for many. We recommend keeping good documentation on issues to keep in mind for future offerings of the course and building strong communication between instructors and students, between students and other students, and between instructors and other instructors within the same institution or across different institutions.

Virtually together but physically separate?

Although remote teaching may be the only viable option for some instructors, others have more flexibility in formatting their course. For *Virtual People*, we had to consider available resources, feasibility, physical restrictions, and other factors to decide whether we were keeping the class physically together, separate, or hybrid.

Each method of course delivery comes with its share of advantages and disadvantages. On one hand, staying completely remote resolves complications such as having audio overlap and not having sufficient space for students to move around. Remote instruction also provides flexibility in commuting to and from class and, as a result, saves time. On the other hand, remote troubleshooting takes longer, as the instructor does not have direct access to the headset. Furthermore, remote learning has historically been afflicted by a higher chance of distraction, an overdependence on technology that leads to interruptions in the learning process when technological malfunctions occur, and a lack of social interaction (Sadeghi, 2019).

Being physically together may allow for naturalistic interactions before and after class, such as walking to class together or staying after class to chat. Furthermore, face-to-face interactions may make up for the verbal and nonverbal cues that get filtered out in social VR, which are critical in providing social and contextual information (Burgoon et al., 2002). At the same time, sharing the same physical space while in VR gives rise to new challenges, such as not being able to separate audio from those physically and virtually around you, multiple microphones picking up the same sounds from the physical world and playing recursively in the virtual world, a need for sufficient physical space for students to move around in, access to ample outlets to charge headsets, and more. Furthermore, being physically together introduces a whole new question of: why VR at all? What are the instructors and students doing that makes it necessary for it to be inside VR, if face-to-face interaction is an option? As highlighted earlier, what kind of content or experience is planned for the course matters, and it is important to consider if VR is the best medium to deliver the material.

Alternatively, the third option is a hybrid course. Our other course, *Into the Metaverse*, incorporated both remote and in-person components, with students meeting either in Zoom and VR, in person and VR, or purely in person. Additionally, our most recent offering of *Virtual People* (see Figure 2) also had an in-person and virtual component, in which the lectures and delivery of the course material took place in person, and the

discussions between students took place inside VR. We found the hybrid model to work best for the nature of our courses for several reasons.

First, in a hybrid model, we were able to onboard students easily and without many issues, and still troubleshoot in person when needed. Having both options provided flexibility for both the instructors and students. Second, students were able to interact actively with the medium they were learning about. They were able to engage in experiential learning, meaning they were learning by doing, rather than learning about VR from a purely theoretical perspective (Kolb, 2015). Remote instruction allowed for this to happen, as going into VR together in person raised challenges such as audio overlap and violations of physical space. Lastly, having a hybrid model allowed for various forms of social interactions to take place that may have been lacking in a purely remote or in-person environment. Given the importance of being active in interacting with others during the knowledge-construction process (see work under the Constructivist Theory, in particular Dewey, 1986; and Engagement Theory, in particular Kearsley & Shneiderman, 1998), having both a remote and in-person component allows for what may be lacking in one to supplement the other.

How much time should we spend in VR?

In line with our previous argument that it is critical to consider if VR is the best medium to deliver the relevant course material, it is equally important to consider *how much*, or the frequency at which students will be using VR. Will VR be used for every class? Will VR be used for the whole duration of one class?

As iterated earlier, we wanted to allow students to have hands-on experience with VR while also connecting with others in the class. We wanted to expose them to the diverse use cases of VR, such as social interaction, empathy, sports training, and climate change. In other words, the majority of what was done during and outside of class revolved around spending time with VR. We recognize that there are very few courses in which VR is the central topic. The reason we used VR in our courses may be very different from the reason other instructors want to use VR. We recommend instructors to consider how, and to what extent, they plan on integrating VR into not only their course material but also the duration of the course.

Previous research cautioned against focusing on learning outcomes that may be confounded by the novelty effect. In other words, positive outcomes of using VR in classrooms may be driven by students' interest in the new technology, rather than its affordances (Beck et al., 2023). In line with what is iterated in the section "Finding the right material and tasks," it is just as important to evaluate how much time should be spent inside VR.

On a session level, our case study revealed that having too many tasks done inside VR may exceed the recommended half-hour mark before users start feeling simulator sickness. Spending over 30 min in headset per session may also lead to cognitive overload, as students need to juggle the learning material and the highly immersive environment (Han et al., 2022). On a course level, the longitudinal field studies that we conducted alongside *Virtual People* may lend a hand in understanding how students' attitudes and behaviors change as they grow familiar with VR (see Han et al., 2023, for more details). Our findings suggest that with time and use, students may be able to focus

more on being present and pay attention to their surroundings, rather than focus on learning how to use the medium. With comfort comes familiarity, and once the novelty of the medium wears off, students may be able to reap the advantages that VR provides. In other words, time and experience matter and should be considered when instructors consider how VR fits in with their desired learning goals and how many "doses" of VR they would like to inject into their course.

Conclusions

Research has shown that VR can be used as a solution to many of the challenges that come with virtualization. Given its unique affordances, including presence, immersion, and avatar representation, VR is a promising tool in domains where social interaction is key. One such domain is remote learning. However, implementing VR into a course curriculum and bringing students into a virtual classroom come with unanticipated challenges that have yet to be covered by researchers. Here, we presented pedagogical observations made during *Virtual People*, one of the first and largest courses offered inside VR.

As compelling as VR can be as a tool to resolve or bolster the holes of classroom curricula, it comes with a myriad of challenges and issues. Before diving headfirst into the virtual world, thorough planning should be done outside of the headset. On a fundamental level, instructors should consider why, how, when, and where to use VR. These will be largely informed by the parameters highlighted earlier, such as the class size, availability of resources, learning goals, and length of the course. On an application level, instructors should consider how they plan on acclimating and accommodating students into VR. Here, instructors may serve as a guide for the students, but they may also be the ones being guided as they tread unfamiliar territories. A collaboration between instructors and students, between students and students, and between instructors and other instructors may be required.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by National Science Foundation [Grant Number 1800922].

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