Developing an Ethical Framework for Virtual Reality Design and Implementation in Technical Communication

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Abstract

For those working in technical fields, the promise of Virtual Reality (VR) to provide engaging experiences that go beyond typical learning modalities has enormous potential to expand how we communicate with a variety of audiences. However, as is common with emerging technologies, intentionality, strategy, and ethical considerations attached to VR need to be designed from the ground up, rather than as an afterthought. In this paper, we offer one framework for building ethics into the design of Virtual Reality experiences to ensure that the process is centered in community and student needs. Grounding our work in an advanced water purification VR project that we created with our students and Immersive Experience partners, we share the ethical framing, course sequencing, and engagement strategies that we employed to ensure an ethical design.

CCS Concepts

• **Human-centered computing**; • **Social and professional topics**; • **Applied computing**;

Keywords

Virtual reality, ethics, community engagement, water conservation

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1 Introduction

Virtual reality is a powerful technology for delivering communication that immerses audiences in places, environments, and situations that they may not otherwise have access to, affording us the opportunity to enhance learning. However, the complexities of design, accessibility, and impact require that practitioners approach VR with care and consideration to ensure that the technology is produced in a way that is consistent with ethical standards of the field, particularly when we are working in these new modalities with students. While there is a growing body of literature that offers suggestions for how to design and implement virtual environments, more work is needed to show how programs can integrate an ethics-forward approach to those projects into a sequence of courses. Building on studies that offer specific models for student engagement with VR [1, 2], this paper shares the design of a virtual reality design project, sequenced across four courses, framed through the lens of an ethics-forward approach to producing virtual reality spaces.

In their work on building community-engaged research into their UX courses, Lee, Turner, and Rose [1] outline three models of partnering courses with organizations, including the "one-to-many model" (p. 31) where one organization partners with multiple classes. Employing this model, our team created a plan for partnering four TPC/UX courses with the Arizona Water Innovation Initiative (AWII), a state-funded initiative focused on developing innovative solutions to water scarcity in the desert Southwest [3]. Our team was awarded a $100,000 grant from AWII to create an immersive VR experience to illustrate advanced water purification (AWP), a process that takes the wastewater that flows down the drains of homes and businesses and cleans it back into the highest quality drinking water before reintroducing it into the community's drinking water supply. As Arizona finds itself in a 2-decade long mega-drought, there is a burgeoning belief that "water is too precious to only use once" [4] Thus, rather than this VR experience being an exercise in casual learning or entertainment, there exist serious benefits to ensuring that we are able to connect with residents and educate them about the Advanced Water Purification process.

This paper outlines the background research, design, and ethical framework we used to help ground students in the needs of both users and stakeholders and maps the existing literature to six core guidelines that we used to create a sense of continuity and ethical investment across four courses working on the project simultaneously. In sharing this process, we hope to trace VR literature through our framework components in a way that both adds to the

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TPC conversation on ethics and VR and encourages new conversations in the direction of ethics as our field continues to expand into using this technology more regularly.

2 Project design and context

Because a framework devoid of context separates the work we do from the impacts it has on both our scholarly and local community, we will start by overviewing the project and our stakeholders in more depth. The Arizona Water Innovation Initiative (AWII), is a $45 million state and foundation-funded effort focused on developing innovative solutions to address the state's current and future water challenges [3]. Our grant team is made up of faculty members who teach Technical Communication and User Experience as well as a team of paid student developers employed through a VR lab at our university and responsible for the technical development of the experience. Our primary subject-matter experts and stakeholders are members of a local municipal water provider that currently operates one of the state's three AWP plants, with several similar municipal plants approved for construction around the state in the next few years. The technology that makes this process possible has been proven safe over the last several decades in communities who have implemented it in California, Virginia, and Texas. But, as Peter Annin illustrates in his book *Purified: How Recycled Sewage Is Transforming Our Water* [5], public perception about drinking processed wastewater, and the "yuck" factor that accompanies it, is perpetually the largest barrier to a community water provider being able to incorporate these processes on a broad scale. Other factors, including previous experience with unsafe drinking water by immigrants in their home countries, as well as historical environmental injustices experienced by marginalized communities in the US, provide additional challenges toward the acceptance of AWP, but also additional opportunities to take an ethics-forward approach to addressing those injustices. To begin what we have envisioned as a multi-stage approach to these myriad challenges and audiences, and in light of our choice to employ virtual reality technology, we decided to start by prioritizing an audience of middle, high school, and university students for whom we would design a fun and educational experience that promotes curiosity and trust in the AWP process.

This project sought to leverage virtual reality assets for the dual purpose of: 1) creating a learning experience that allows users to explore an advanced water purification plant and 2) providing a learning experience for students in Technical Communication courses to contribute to the design of the VR experience. In addition to partnering with many stakeholders to understand the scope, constraints, and learning objectives of the project, we matched four of our core classes (outlined in Table 1 below) with the needs and deliverables of the project to offer our students a hands-on experience working with VR technologies. Our general course sequence involved: 1) An introductory level Technical Communication course (TWC 501) whose students would be responsible for researching and analyzing the script as a technical document, 2) a User Experience course (TWC 544) whose students would be responsible for researching and defining user needs and assumptions, as well as user testing various game elements as they are developed, 3) a Visual Communication course (TWC 511) whose students would be responsible for designing a style guide and visual aesthetic for the experience, as well as marketing materials to publicize the eventual finished product, and, 4) a Data Visualization course (TWC 514) whose students would work on designing clear and simple data visualizations to be embedded within the game as well as communicating use data from the VR experience to community and stakeholder audiences. The goal in shaping the ethical framework explained in this paper was to offer a common starting point for the students and stakeholders to engage working with the project across multiple disciplines and deliverables. With students in mind, the following sections will contain a literature review, ethical guidelines, and a table linking the two with shared readings and outcomes for VR learning.

3 Literature review

Although there are multiple definitions for what constitutes Virtual Reality, how it is distinct from Artificial Reality, Augmented Reality, and other kinds of "virtual worlds," most definitions describe VR as containing a significantly more immersive component in a fully-constructed environment, as opposed to other modalities [6]. While virtual reality as a learning modality is expanding as more institutions gain access to the technology, the value of creating virtual experiences to enhance learning outcomes is mixed. At the turn of the century, Thrush and Bodary noted that VR would likely redefine the field of technical communication, noting that this "technology developed for play may eventually change the way we work" (p. 327) [7]. While certainly VR has proliferated in terms of use and access, there has been a mixed reception to the technology as a viable learning modality. As late as 2017, Robinson *et al.* found in a corpus review of technical communication topics that only 1.6% of studies collected for the research centered on AR/VR research [8]. Three years later, that same research team found both a commitment to and an apathy around VR [9]. Tham [10] similarly notes that VR has both benefits and limitations, given the complexity of capturing sensory experiences.

Because virtual reality incorporates components that tap into experiences that build on, extend, or reframe the human experience, one component of determining what makes VR successful or unsuccessful–or worth our commitment or apathy [8, 9]–is whether or not it can align with our expectations of what constitutes a powerful user experience. In our roles as TPC scholars and practitioners, we are aware of the power that shaping these experiences has and the work that our choices make in the world. Because of this, we seek to understand our role in creating experiences that are as ethical as they are impactful. We ask not just how to create a deeply sensed and memorable learning opportunity through VR. More importantly, we ask *who*: for whom does VR create a powerfully felt and memorable learning experience, and for whom does it *not?* Thinking about technology and the circulation of power that follows in its wake is part of what prepares us to remain accountable to our communities [11], avoid considering technology in a vacuum [1], and allow us to act as advocates for social justice through the technologies that we shape [12]. To ensure that our VR project is grounded in these core goals of TPC work, we review literature at the nexus of three areas (Ethical Framing, Designing and Collaborating, and Listening and Responding)[13] and follow

Table 1: Course Virtual Reality Integration Overview

Course Title	Virtual Reality Course Tasks
TWC 501: Fundamentals of Technical Communication	Researching the technical aspects of this process Consulting with subject matter experts Examining script as a technical document Working with the development lab to write a script that makes choices about what to include in the context of what we know about the audience
TWC 544: User Experience	Understanding audience Assessing audience assumptions, needs, and understandings Testing the script and visual assets with users Ensuring accessibility for users
TWC 511: Visual Communication	Ensuring visual accessibility for a range of audiences Working with the developer to design the style guide via mood boards, visual elements, and marketing
TWC 514: Visualizing Data and Information	Visualizing data throughout the experience Learning what people are capable of managing during an informal learning experience Visualizing user data

with two guidelines in each area chosen to tether our one-to-many [12] design to a unified, ethical framework.

3.1 Ethical framing

When considering launching a VR project in TPC and UX, understanding how our existing values and those we were trying to serve could be used to frame our engagement with emerging technologies is an essential first step [13]. Because the people who are responsible for the development of the virtual reality experiences are focused on the production side, those working in TPC must act as leaders in ensuring that ethical and community considerations and design choices are incorporated. For our intro class, the focus is on synthesizing a technical process with community lived experiences and assumptions; for our UX class, the focus is on understanding users and researching their experiences with game elements and eventually with the game itself; for our visual communication class, the focus is on the careful visual representation of characters, elements, and processes in an ethically-aware manner; and for our data visualization class, the focus is on curating which data should be represented in which styles within the VR experience, as well as communicating the experience of user engagement data authentically to stakeholders.

Both Blakesley [14] and Tham [2, 10] acknowledge that Virtual Reality constitutes an opportunity in which students can practice both digital and ethical literacies through a critical lens. While learning the mechanisms that underlie VR benefits students in its own right [15], the factors that surround the use of the technology are rich with areas of technical and rhetorical invention for students preparing to enter our field. Miles [16] speaks to the importance of audience and embodiment in teaching students in VR environments, Lueck and Bachen [17] highlight the need for careful consideration of language and vocabulary in designing VR, and Lucia et al. [15] argue that a focus on rhetorical elements of VR and building experiences from the bottom up, rather than the top down, are all important ways to frame experiences for audiences and students working on their design. Offering a specific strategy for working with students in VR environments, Misak [18] offers the idea of "meta-strategic knowledge" that helps students establish a sense of narrative and place in VR work, and Blevins [19] invites the use of "layers" (communication, social/cultural, etc) to investigate how different needs, contexts, and processes overlap to facilitate an experience for the audience. Each of these constitutes one way in which an ethical approach to framing VR as a concept can be established before the design work begins.

3.2 Designing and collaborating

Only after we have considered questions about what the affordances and limitations of VR mean for our field, our experience, and our capacity to learn through new mediums, should the user-centered design process begin. While VR technology involves many layers of design in order to create a coherent and impactful experience, Bronack [20] considers three to be at the center of these decisions: 1) Design of space; 2) Promotion of presence; and 3) Unique human behaviors within the space. Taken together, these three dimensions account for how bodies are going to move through the space of the room as well as the level of embodiment needed to make that experience successful. While these recommendations revolve around use of space, Verhulsdonck [21] also argues for a focus on non-verbal gestures, as they link movements and agency within VR spaces. In addition to these major considerations regarding space, Araki and Carliner [22] offer a set of considerations that invite practitioners to consider the variety of roles that go into spacing a VR experience, highlighting the role of the developer, information delivery, and communities relating to content. In the context of our water purification plant VR narrative, we were invested in making sure that the characters, content, and narrative elements of the experience were responsive to the needs of our initial target audiences in Arizona facing an uncertain water future, and could be designed in such a way as to be inclusive of the needs of future audiences (or able to be modified to meet future audience needs).

When working with students on VR projects, offering them experience in negotiating work with multiple other teams or individuals with varying expertise prepares them for a variety of potential paths. In his recent work on VR, Jason Tham [23] outlines five broad considerations for VR design including Interactivity (social engagement of VR), Reach (availability to diverse users), Usability (capacity to develop a desirable experience), Positionality (ethics and values related to design), and Tactics (ability to respond to challenges) (p. 12). In creating this, Tham offers a field guide for students and practitioners who are entering VR spaces to design with their communities in mind, which centers TPC values in VR work. When developing our experience, we considered these elements and how they worked together to create a narrative that was engaging and introduced the idea of AWP as safe and trustworthy. For example, ensuring that our initial target audience of middle school through college students had fun using the VR technology (usability) strengthened our ability to impact current and future audiences and community members (reach).

3.3 Listening and responding

User-centered design, in VR and in TPC more broadly, focuses on iteration. Because the future of VR is not yet clear–given the mixed results of the experiences and their impacts–a focus on iteration is all the more important to ensure that materials are meeting the needs of the audiences and communities they are designed to serve. Although many of the considerations discussed here are also design considerations that should be built in from the ground-up (for example, accessibility [24]), this section focuses on how designers and students engage a process of listening and responding to needs of audiences and users of VR technologies. For example, Rojas-Al Faro [25] argues for the importance of user feedback in creating an inclusive environment that engages a variety of users with different spatial, social, and learning needs.

One technique that encourages a version of listening involves the use of "retroactive narrative maps," which can be helpful for understanding the in situ use of space [26]. Applying this technique to VR can result in maps that outline space in multiple dimensions, including physical space as users go through a VR experience and virtual space as users navigate content. Further, Padmanabhan [27] discusses the need to customize assessment criteria to the project at hand, which is an important exercise to do with team members and stakeholders at the beginning of a project. This ensures that the experience is delivering on what it is intended to, or that a new meaning or purpose is co-constructed with the audience and users who are adapting the experience to their needs as learners (or perhaps both). In our case, iterating the script involved multiple meetings with the design team, students working on the production of the VR experience, and community members participating in focus groups to provide prototype feedback.

4 Framing ethics in virtual reality

Because we both a) believe in the public value that advanced water purification can provide and b) believe in the use of VR as one modality to enhance education, our goal was to design an experience with community engagement and ethical framing at the center of our work. Ultimately, we sought to design and assess a VR experience that contributed to local understanding of how water purification works, and to do so using an ethical framework throughout the process. To explain the relationship between the literature review, the principles we outline, and possible applications, the table below (Table 2) provides a road map of the ethical framework we used in developing our VR project. This outline has three major content areas (Project Framing, Designing and Collaboration, and Listening and Reporting), associated readings for each concept, two central guidelines that we followed within each concept, and a list of goals or applications. Our goal is to not only outline how we designed our one-to-many VR course experience, but also to provide a resource for others who might be formulating their own experiences. After the table, each of the six VR guidelines that we outline are discussed in more detail.

4.1 Grounding VR in a purpose/problem

Virtual reality has a persistent air of the novel. Even though virtual reality products and environments have been developed and deployed over the last forty years, none have reached mass appeal and cultural integration. Many teachers and students may have limited or no experience with virtual reality experiences. Thus, virtual reality deployed in an educational setting has the possibility of being deployed as a novel standalone experience–a product or experience that captures the attention and interest of the faculty and student body, but is not deeply integrated into the course. This sort of novelty approach has limited effectiveness [9, 18].

Instead of pursuing a novelty approach, VR experiences should be grounded in a purpose or problem. Virtual reality experiences are specific types of tools that can solve specific sorts of problems, and can be used for specific purposes. Giving students an ability to virtually go somewhere (such as a water purification plant) that would be challenging to gain physical access to for training is one problem that a VR experience can address. Training for work in high-risk locations, such as a nuclear reactor or an active medical facility, can be done in virtual reality at a greatly decreased risk to bystanders or peers. Slowing down extremely fast processes, speeding up extremely slow processes, or allowing processes of any speed to be stopped mid-process (for example, as water advances through each step of the purification process) are also areas where VR experiences can offer benefits to education. Introducing concepts that are challenging or abstract in dynamically visual, semiotic, and narrative ways that allow students to interact directly with content allows new ways of knowledge acquisition. Relatedly, giving students the ability to engage with and interact with virtual experiences using recently acquired knowledge can reinforce the learning in unique and distinctive ways.

Thus, those who are user testing virtual reality experiences for education must think about not just the actual experience, but its relationship to the work of the course. What problem is the virtual reality experience trying to solve in this course? What purpose does the experience serve? Are users going through the experience understanding the purpose of the VR program? Does the faculty feel that the problem the VR experience was intending to solve is actually solved? If faculty do not see the problem solved or students not see the purpose of the VR experience, where is the breakdown occurring? What course or program outcomes are being served

Table 2: ***Core Concepts, Readings, Guidelines, and Outcomes in Virtual Reality Design***

Core Concept	Readings	VR Guideline	Outcomes
Project Framing	Tham et al (2018) Blevins (2018) Lee, Turner and Rose (2022)	Grounding VR in a purpose or problem (4.1) Course Sequencing (4.2)	→ Encourages use of VR as a tool rather than a novelty → Reinforces learning as part of a larger educational picture → Offers context and scaffolding to support larger learning goals → Ensures that VR is integrated in a way that connects learning experiences and content
Designing and Collaboration	Bronack (2008) Lucia et al (2023) Tham (2024)	Collaboration and stakeholder alignment (4.3) Accessibility (4.4)	→ Provides students with an opportunity to learn about project management and mitigating breakdowns in the process → Increases exposure to and work with external partners as part of professional preparation → Strengthens understanding of designing for diverse audiences and accounting for a range of needs → Promotes thinking about the affordances and limitations of space to accommodate different experiences
Listening and Responding	Padmanabhan (2008) Kitalong et al (2009) Rojas-Al Faro (2024)	Testing (4.5) Addressing user problems (4.6)	→ Involves careful planning of context and setting to conduct user testing → Develops agile and flexible framework for assessing needs → Challenges students to solve problems and innovate solutions → Promotes careful listening and understanding audience concerns

(or not served) by the experience? Identifying user experience problems with virtual reality is not just about the interfaces, but about the contextual fit of the experience with student needs and faculty goals. In this case, our goal of having students learn about VR and also learn about specific user audiences for a particular purpose was met by the water purification plant VR experience.

4.2 Course sequencing

In addition to grounding a VR experience within the context of a need for the course, the virtual reality experience should be sequenced into a course. The experience should be not be dropped into a syllabus with no context; instead the experience should be scaffolded such that the students are prepared for the content and technical aspects of what they will experience, debriefed once the experience has happened, and moved past the experience into further content related to the experience *and* the course/program outcomes [16]. For example, each course in our four-course sequence were working on larger water projects in Arizona, and VR represented one piece of a larger narrative about community water needs addressed through the courses. Ultimately, virtual reality experiences should be treated like a reading, resource, or in-class activity; each of these work best when they are fully integrated into the learning experience. When well-integrated, students will be prepared to learn from the experience, learn while in the experience, and extend that knowledge after the experience.

This focus on course sequencing means that adding virtual reality to a course requires more work than adding a day for VR; it will require multiple days' worth of class that integrate the experience into the overall work of the class and pedagogical experience of the student. This type of work takes effort and restructuring of the course; it may mean adapting or dropping other topics. In short, it is a big effort to add VR to a course ethically and effectively, and adding a VR experience should be done with this potential concern in mind.

This focus on integration into the course extends the concerns about understanding the fit of the experience into the course at a macro level. Where the problem to be solved is the macro concern, the integration of the VR experience on a day-to-day basis is a more micro concern. User testing a virtual reality experience, then, requires an understanding of what the course flow looks like, what the course expectations are for the students, and what the day-to-day work of the course looks like. If a virtual reality experience isn't reaching the purpose or solving the problem it is intended to solve, analyzing the experience's fit in the course is a place to evaluate [17]. Is the scaffolding effective? Are the students adequately prepared? Is the debriefing connecting what they have experienced with previously learned material? Are students understanding the further steps connecting the experience to new content in the coming classes? These types of questions can help define where and how the sequencing of the class is limiting the effectiveness of the virtual reality experience. Because our project involved multiple classes, ensuring that our sequencing was working not only in our own classes, but also as a VR integration across the curriculum required frequent communication.

4.3 Collaboration and stakeholder alignment

Another area to discuss when considering the effectiveness of virtual reality experiences is the collaborative aspects. Virtual reality experiences require a large amount of technical expertise, narrative expertise, time, and finances. Because so much is required for a successful VR experience, many virtual reality experiences are deeply collaborative affairs [22, 23]. As a result, not everyone on a VR team will likely have a full grasp of every concept in the VR development process. Assessing the effectiveness of a VR experience extends to understanding who is in charge of what aspects of the project and whether all the collaborators are working together effectively. Given the large amount of project management that goes into a collaborative effort such as this, understanding breakdowns in workflow, collaborative activity, technical delivery, and interpersonal relationships can give insight into why certain aspects or even a whole VR experience are not reaching their full potential. Working through collaboration concerns and identifying ways of mitigating any potential struggles can help VR experiences move in a more effective direction.

Beyond the development team, VR experiences often have a stakeholder or stakeholders involved in the content development or content deployment. Subject matter experts may be brought in to consult on issues related to the content. The university representative or representatives (faculty, staff, or administrator) who are representing the university's educational interests may be involved in content creation. The faculty who will be deploying the content in a course will be involved to some extent. External partners may be involved at varying levels for various technical, financial, or narrative reasons. All of these relationships need to be aligned and clearly delineated; breakdowns in these relationships can cause part or all of a virtual reality experience to be under-effective or even derailed.

For this reason, we incorporated interviews and class visits from subject matter experts, water stakeholders, high school teachers and students, and development team leaders. Testing the user experience of a virtual reality experience should extend to understanding these relationships; understanding how these relationships work will inform how the experience was made, and can shed light on areas that are not succeeding within the virtual reality experience. Thus, stakeholder management is another potentially unexpected area that user testers of virtual reality experiences should evaluate as part of the user test.

4.4 Accessibility

In addition to understanding the goals of the VR experience, the fit of the program in the course sequence, and the collaborators and stakeholders' relationship to the project, a user tester must understand the audience for the VR experience. Understanding the intended audience can help clarify issues related to the previous items mentioned above, but it also allows for a starting point for understanding the accessibility of the VR experience [25].

Determining what the intended audience is for the VR experience can allow the user tester to determine whether the VR experience can actually be used by that audience. For example: if a VR experience is being made for community members, or students in a college class that has an on-ground and online version, care should be taken to make sure that a downscaled version of the experience that can be seen on a 2D monitor is available for online students who may not have access to a VR headset. If the VR experience is intended to be conducted while seated, user testers should make sure that the seats for the VR experience are flexible and accessible for all body types, up to and including being able to remove the chair for those who are in wheelchairs. If a person is required to move in a VR space, then making sure the path or area is free of obstructions for those in wheelchairs or with mobility concerns is necessary. Areas requiring motion will require many further considerations regarding physical space and accessibility: guardrails, ramps, and the ability to deliver information should a person need to leave the VR experience/space, among them.

The user's experience of virtual reality headsets is another area of accessibility that needs to be considered by user testers. Considering the weight of VR headsets, the amount of time in a headset should be a consideration; some people may tire faster than others when keeping a heavy headset on for a set amount of time. Given the large amount of visual input and the closeness of the VR screen to people's eyes, user testers should check that people are not experiencing any physical consequences of the headset. Headaches, nausea, dry eyes, and tired eyes are common physical symptoms of VR headset use. It is important to have the content of the VR experience available in multiple formats (including 2D downscaling) for those who experience these issues, and make users aware of these potential side-effects ahead of time by including them in emailed consent materials. There is currently little knowledge on how to design to avoid these problems for users, but research is ongoing.

Given the visual element of the VR experience, working with those who wear corrective lenses (glasses) should be an important part of user testing. Can the headset be worn with glasses? If the user can't wear glasses in the headset, will the user be able to see the experience effectively? If the user can wear glasses in the headset, how do the headset, the visuals, and the glasses interact? These are questions that user testers should ask when evaluating the user experience of VR. Giving students the ability to practice asking the right questions during a VR water purification experience offers one way to test out what kind of answers students hear back from users about VR, and how they cover, or fall short, of the information they need to best inform modifications. For our water purification VR experience, conversations about accessibility began during the development of the script and informed our choice to have both a seated experience and a 2D version, and continued through our students working on user testing. Ensuring questions about how users with glasses, for example, were reacting or experiencing the technology differently was part of what went into our evaluation metrics.

4.5 Testing

With all of these considerations brought into the mix, there is still a need for actual testing of the VR experience. Putting users into headsets and asking them to participate in testing is a critical need. This testing can be done in multiple ways [27]. Some VR experiences are designed for multiple people to experience at once; some experiences can have 30 or more people in them simultaneously in their final form. While testing a program in the form in which it will be used is valuable, starting with large numbers of users in the experience is not ideal, especially if testing is being conducted at an early stage of the VR experience development.

Instead, beginning user testing with a single user and a moderator who are both in the experience (in the headsets) is a good way to begin. The moderator can see what the user is seeing and watch the user in the virtual reality space. The moderator can choose to ask the user to do the traditional speak-aloud protocol, or conduct tests that ask the user to attempt to conduct the experience, then debrief. The speak-aloud protocol in VR can be a bit challenging, because VR experiences often have sound playing with the experience. While multi-user experiences can and often do have microphones that allow users to interact orally with each other in the experience, this conversation is not always the easiest to understand (due to ongoing music / sound effects). Testers conducting speak-aloud protocol should do their best to hear and record the comments the user is making, but know that there will be limitations to the speak-aloud aspects.

Taking notes in VR is a challenge, as the tester can write while in VR, but will not be able to see what they are writing when in the headset. This can produce unruly written notes. An ideal situation would be a person outside the virtual reality headset who is watching a monitor that can see what the user is seeing and is wearing a microphone setup to talk to and hear from the user. This setup is not always possible, and users should do the best with what they have.

In situations where the challenges of conducting a speak-aloud protocol are too high to get data, testers can ask the user to go through the experience and then debrief with questions at the end. This can be done with the tester in a separate headset going through the VR experience with the user, outside the headset while watching a monitor, or fully outside the experience (waiting for the user to finish the experience). The debrief then could take place after the experience has completed, and the types of questions asked in the debrief could be driven by user experience concerns (what did you find difficult, what was easy, were there broken areas, were there things you wanted to do but could not, etc.).

Questions for the user should reflect their experience and reflections on the content, their emotional experience of the VR experience, their physical experience of the VR experience (attendant to the accessibility issues raised above), and general UX test questions about quality and pain points. The questions that a VR user tester must ask are not all that different from traditional website or video game user testing, but the added VR aspects do require balancing more concerns than usual [26, 27].

Once testing has been conducted with individuals, it is wise to move to testing the next version of the product with small groups (2-3 people) if the VR experience will have more than one person in it simultaneously as an end product. All of the challenges above about sound in VR interfering with think-aloud protocols are heightened here, and debriefing may be a better option than trying to have everyone do think-aloud protocols. The debriefing from these experiences can be individual debriefs conducted sequentially or simultaneously by multiple researchers. In our case, having one group of students act as initial users for the UX class offered a way to begin the process before reaching out to a broader audience of users.

If the product will have many people in it, successive rounds of user testing should increase the number of people in the experience until a test has been done that has the target number of people that the VR experience aims to host at a single time. If this results in a testing session of 4-9 people, a focus group style setting may be a valuable way to debrief; if the experience has 10+ people, an online form may be the best way to do the debrief and capture user experience information. This may reduce some of the richness that a more interactive debrief might deliver, but ideally the worst problems of user experience will have been eliminated in earlier rounds of testing, and the reports from the users will not need to carry the same amount of richness. If there are issues of scale that didn't appear at an earlier stage of testing, picking a few people to debrief with directly may be an appropriate way forward to do debriefing to gather information.

4.6 Addressing user problems

Identifying user experience problems in virtual reality experiences starts with an analysis of the functions of the VR experience in its intended context. If the user experience of a VR program is not succeeding, making sure that the concept of the experience fits with the goals comprises the first step. Whether the solutions to user problems come in the form of re-designing the experience from the ground up [17], making smaller changes to enhance usability, or finding an alternative way to deliver information, focusing on solutions rather than relying on the novelty or interest in VR alone may help the technology use have longevity. If user issues are not addressed, at some point the technology will cease to be used, and both educational and development progress will be unlikely.

Addressing user problems in VR begins similarly to addressing user problems in any user experience situation. Centering the needs of the users, ensuring that the necessary resources are appropriated to make the necessary changes, and using an iterative process to address concerns should all be a part of the process. Ideally, any changes that are made to enhance the experience of the user would begin the testing cycle anew to ensure that the adjustments had a meaningful impact on the use of the virtual space. In the event that user needs are identified after the production of the environment, feedback from users may need to be incorporated into subsequent projects, increase the support or guidance given to users who are about to experience VR, or result in the production of a new environment re-designed to accommodate the needs of the audiences using the system [2, 10]. Because the goal of reaching audiences about water issues is multifaceted, this multi-step approach will likely be needed in our project to address the complexity of the topic and situation.

Listening to and addressing user problems is an essential step in particular for students who might be working on Virtual Reality projects. Whether these students end up working in VR contexts or in other sectors that involve emerging technologies, it is important that the cycle of design is complete through the stage of addressing problems to avoid the idea that those working in design contexts create one version of something and then leave it, never to return. Rather, we need to encourage our students to think about how they would respond to user testing, rather than instructing them in the methods of testing without intent to resolve or make changes to what users are experiencing. While the most articulated version of this would be in returning to the design phase to create changes, addressing user problems can also take the form of providing additional information about the use of the VR, creating plans for fixing issues through additional or external design, or considering what content is lost in delivering the final messages associated with the VR if the experience is not meeting the needs of the users it's designed to serve. While we iterated throughout the design of our water purification plant VR experience, our commitment to creating multiple VR experiences, with future plans to develop nuclear plant and extreme weather VR scripts, ensured that we could continue to refine the process as we gained more experience and learned more from users about what works and what is needed from the audience perspective.

5 Conclusion

Virtual reality is an exciting technology to enhance learning in unique contexts. Without grounding in ethical approaches, it has the potential to be a technology without a community or home. We believe that our water purification VR experience can help audiences experience water in new ways that would not be available through other mediums. Yet we cannot lose sight of the fact that this VR experience exists as one element of a larger and more complex community story of what water means. In addition to ensuring that the technology is successfully matched to its purpose and audiences, ensuring that these technologies are carefully designed for our students is also important, as we prepare them to work in these contexts. Specifically, because VR technology is "in flux, it currently offers students the opportunity to work with a clearly changing technology that prepares them to focus on broad theoretical concepts rather than concentrating primarily on the step-by-step process of a particular composing technology" (p. 22) [19]. We have an opportunity to advance our field's values through a new technology and benefit our students and our communities in doing so, if care is taken to ensure that it is done well.

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References

[1] Soyeon Lee, Heather Nicole Turner, and Emma J. Rose. 2023. Community-engaged user experience pedagogy: Stories, emergent strategy, and possibilities. *Communication Design Quarterly Review 11*, 3, 28–41. https://doi.org/10.1145/3592367.3592371

[2] Jason Tham, Megan McGrath, Ann Hill Duin, and Joseph Moses. 2018. Guest editors' introduction: Immersive technologies and writing pedagogy. *Computers and Composition 50*, 1–7. https://doi.org/10.1016/j.compcom.2018.08.001

[3] Arizona Water Initiative website https://azwaterinnovation.asu.edu/ Accessed May 30, 2024.

[4] Babbitt, B. (n.d.). "Water is too precious to be used only once." Retrieved from MAVEN's Notebook: https://mavensnotebook.com

[5] Peter Annin. 2023. *Purified: How Recycled Sewage is Transforming Our Water.* Island Press.

[6] Anthony Scavarelli, Ali Arya, and Robert J. Teather. 2021. Virtual reality and augmented reality in social learning spaces: a literature review. *Virtual Reality 25*, 1, 257–277. https://doi.org/10.1007/s10055-020-00444-8

[7] Emily Austin Thrush and Michael Bodary. 2000. Virtual reality, combat and communication. *Journal of Business and Technical Communication 14*, 3, 315–327.

[8] Joy Robinson, Candice Lanius, and Ryan Weber. 2017. The past, present, and future of UX empirical research. *Communication Design Quarterly Review 5*, 3, 10-23.

[9] Candice Lanius, Ryan Weber, and Joy Robinson. 2021. User experience methods in research and practice. *Journal of Technical Writing and Communication 51*, 4, 350-379. 10.1177/00472816211044499

[10] Jason Tham, Ann Hill Duin, Laura Gee, Nathan Ernst, Bilal Abdelqader, and Megan McGrath. 2018. Understanding virtual reality: Presence, embodiment, and professional practice. *IEEE Transactions on Professional Communication 61*, 2, 178–195. https://doi.org/10.1109/tpc.2018.2804238

[11] Kristie S. Fleckenstein. 2005. Faceless students, virtual places: Emergence and communal accountability in online classrooms. *Computers and Composition 22*, 2, 149–176. https://doi.org/10.1016/j.compcom.2005.02.003

[12] Natasha N. Jones. 2016. The technical communicator as advocate: Integrating a social justice approach in technical communication. *Journal of Technical Writing and Communication 46*, 3, 342-361. 10.1177/0047281616639472

[13] Andrew Mara. 2018. Framework negotiation and UX design. *Communication Design Quarterly Review 5*, 3, 48–54. https://doi.org/10.1145/3188173.3188178

[14] David Blakesley. 2018. Composing the un/real future. *Computers and Composition 50*, 8–20. https://doi.org/10.1016/j.compcom.2018.07.005

[15] Brent Lucia, Matthew A. Vetter and David A. Solberg. 2023. "I Feel Like I'm in a Box": Contrasting virtual reality "imaginaries" in the context of academic innovation labs. *Technical Communication Quarterly*, 1–16. https://doi.org/10.1080/10572252.2023.2245442

[16] Katherine S. Miles. 2010. Reconceptualizing analysis and invention in a post-techne classroom: A comparative study of technical communication students. *Technical Communication Quarterly 19*, 1, 47–68. https://doi.org/10.1080/10572250903373056

[17] Amy J. Lueck and Christine M. Bachen. 2021. Composing (with/in) extended reality: How students name their experiences with immersive technologies. *Computers and Composition 62*, 1-14. https://doi.org/10.1016/j.compcom.2021.102679

[18] John Misak. 2018. A (Virtual) Bridge not too far: Teaching narrative sense of place with virtual reality. *Computers and Composition 50*, 39–52. https://doi.org/10.1016/j.compcom.2018.07.007

[19] Brenta Blevins. 2018. Teaching digital literacy composing concepts: Focusing on the layers of augmented reality in an era of changing technology. *Computers and Composition 50*, 21–38. https://doi.org/10.1016/j.compcom.2018.07.003

[20] Stephen C. Bronack, Amy L. Cheney, Richard E. Riedl, and John H. Tashner. 2008. Designing virtual worlds to facilitate meaningful communication: Issues, considerations, and lessons learned. *Technical Communication 55*, 3, 261–269.

[21] Gustav Verhulsdonck. 2007. Issues of designing gestures into online interactions: Implications for communicating in virtual environments. *ACM Special Interest Group for Design of Communication: Proceedings of the 25th Annual ACM International Conference on Design of Communication*, 26–33.

[22] Marci Araki and Saul Carliner. 2008. What the literature says about using game worlds and social worlds in cyberspace for communicating technical and educational content. *Technical Communication 55*, 3, 251–260.

[23] Jason Tham. 2024. Researching with virtual reality: Exploring the methodological affordances of VR for sociotechnical research and implications for technical and professional communication. *IEEE Transactions on Professional Communication.* https://doi.org/10.1109/TPC.2024.3378850

[24] Sushil K. Oswal. 2019. Breaking the exclusionary boundary between user experience and access: Steps toward making UX inclusive of users with disabilities. *SIGDOC 2019 - Proceedings of the 37th ACM International Conference on the Design of Communication.* https://doi.org/10.1145/3328020.3353957

[25] Roberto Rojas-Alfaro. 2024. Navigating the stacks virtually: Integrating virtual reality into writing resource instruction. *Computers and Composition 72*, 1-14. https://doi.org/10.1016/j.compcom.2024.102851

[26] Karla Saari Kitalong, Jane E. Moody, Rebecca Helminen Middlebrook and Gary Saldana Ancheta. 2009. Beyond the screen: Narrative mapping as a tool for evaluating a mixed-reality science museum exhibit. *Technical Communication Quarterly 18*, 2, 142–165. https://doi.org/10.1080/10572250802706349

[27] Poornima Padmanabhan. 2008. Exploring human factors in virtual worlds. *Technical Communication 56*, 3, 270–276.