Exploring the Inclusive Design and Use of Social Multi-Platform Virtual Reality for a Post-Secondary Gender Diversity Workshop

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Abstract. This paper explores the challenges and opportunities in creating and using social multi-platform virtual reality to increase engagement and inclusion in a transformative learning workshop for post-secondary faculty. We studied the creation and use of three virtual learning environments and nine virtual learning artefacts in a gender diversity workshop for trades faculty to understand how the inclusion, creator, and subject matter expert communities are involved in creating and using virtual reality learning content. We document our community-design process for creating a virtual reality learning activity and evaluate its use with observational note-taking and informal interviews to capture nine themes around using virtual reality for transformative learning within social learning spaces. Our results suggest that the virtual reality learning activity was engaging and inclusive, showing potential as a transformative learning tool. Based on our findings, we propose a preliminary model for creating and using inclusive virtual reality within social learning spaces to guide future studies.

Keywords: virtual reality, design, transformative learning, inclusion, case study, social learning spaces, gender diversity, skilled trades.

1 Introduction

As a potential solution for more practical experiential and transformative learning, virtual reality (VR) can increase learner motivation, enhance perspective-taking, improve the contextualization of learning, and allow for more effective collaborative learning [1, 2]. However, it is still unclear how effective VR is in Post-Secondary Education (PSE) classrooms beyond skills-based training and virtual recreations of physical classrooms and conference spaces [3], often focusing exclusively on non-accessible Head-Mounted Display (HMD) VR [1]. Additionally, the creators of VR learning activities are often unaware of the communities in which VR will be used [4, 5]. Within this focus on building transformative and experiential learning and the need to engage diverse

groups of learners, we are critical of whether contemporary VR is an inclusive medium, "using proactive measures to create an environment where people feel welcomed, respected and valued, and to foster a sense of belonging and engagement" [6].

An example of transformative learning, where we critically evaluate held assumptions, beliefs, values, and perspectives, opening learners to mindful change [7], is using VR to imagine another's perspective better to create empathy for other individuals and communities, called virtual reality perspective-taking (VRPT) [8]. For example, researchers found that VR can place you in a situation of homelessness to create longer-term empathy for those who are homeless [2] and increase empathy for a partner after experiencing that partner's "day-in-the-life" VR simulation [8]. It is still a developing area, as embodying others in VR experiences may enhance stereotypes rather than reduce them [9], resulting in identity tourism - an "activity of racial identity appropriation" [10]. Still, VR appears to be a powerful tool for transformative learning.

In this study, researchers designed three virtual learning environments (VLEs) and nine virtual learning artefacts (VLAs, virtual manipulatable 3D objects that contain multi-sensory storytelling) to encourage VRPT without the problematic embodiment of others. The VLEs and VLAs were co-designed with the inclusion, creator, and women in trades communities for a workshop that overviews women's challenges in the trades. Additionally, we describe the workshop participant's use of the VLEs and VLAs within the workshop's VR learning activity, which aims to be more inclusive by featuring platform scalability (supporting HMD, mobile, and desktop VR) [1], social scalability (supporting one-many learners) [1], and transformative learning with reflection spaces and VLAs [11] that encourage VRPT. By documenting the design and implementation processes, we add to the literature the challenges and opportunities of developing and using social multi-platform VR experiences in social learning spaces [12].

Our research questions are:

1. *What can we learn from the creation of VR VLEs and VLAs to guide future design and development of VR learning activities?*
2. *What are the challenges and opportunities in using desktop, mobile, and HMD VR to increase inclusion in VR learning activities?*
3. *How do we connect how people create inclusive and engaging VR learning activities with how people use them?*

Our design observations and themed analysis of participants within three pilot studies and one gender diversity workshop allowed novel insights into creating VR learning content, how learners use social multi-platform VR, and the proposal of a model of inclusive VR creation and use in learning.

2 Design Process

After an initial research stage, where we collaborated with the inclusion and women in trades (subject matter experts) communities to define the VR content, we performed an iterative design process to create three VLEs and nine VLAs for a faculty workshop highlighting the challenges women face in the trades.

2.1 Background - Gender Diversity in the Skilled Trades

Despite efforts to further equality and inclusiveness within STEM education institutions and professions, women lack representation within STEM careers and education [13, 14]. Unfortunately, within classrooms, women "are bombarded with subtle (and not so subtle) messages that signal they do not belong" [14], experience a lack of peer support and role models [13], and a lesser sense of belonging. In response, some PSE institutions include diversity training in their curriculum, highlighting inclusion challenges and solutions. Unfortunately, engagement in diversity training is low and may paradoxically increase discrimination [15].

Table 1. Themes identified within subject-area research with the trades' and the inclusion and diversity communities led to the design and creation of several VLEs and VLAs.

VLE	Introductory Questions	VLA	Theme	Narration Audio and Caption
Kitchen *"Growing Up"*	(1) How can we support women considering tech careers? (2) What cultural biases should we be aware of?	Acceptance Letter	Excitement	"Despite their concerns about me getting this diploma in tech., I know it will open doors for me. My parents might not approve at first, but I'll show them it's worth it."
		Parent's Shop Keys	Confidence	"When I was young, the options my parents had were limited. They needed to work long hours for this shop, but I need to find my own path. Maybe my love of working with my hands and building could help automate areas in the shop."
		Math Homework	Frustration	"The idea of taking classes to become an accountant is not what I want. Sure, numbers come easily to me and I'm good at solving equations. But I'm also good at other things, being proficient in math doesn't define me."
Classroom Electrical Lab *"In the Classroom"*	(1) How can we make our tech classrooms more inclusive? (2) What are some strategies for dealing with unbalanced group issues?	Drill	Group Dynamics	"Walking into the lab the first day was exhilarating and terrifying. I'm excited to learn and get comfortable with the tools. But, it's next to impossible when I'm always paired with someone who takes over. I was never exposed to these tools as a child growing up."
		Safety Gloves	Equality	"These glove sizes are almost impossible to work with. Yes, we need these for protection, but I also need to pick up fine objects such as wires and screws. If the school had a greater selection for all sizes, I'd spend less time adjusting and more time working in the lab."
		Instructor's Clipboard	Exclusion	"Mr. Smith always seems more open to chatting about things with the guys, spending more time with their groups than ours. If he knew that I captained my basketball team in high school, maybe he'd ask me who my fantasy picks were?"
Construction Worksite *"On the Job"*	(1) What can we do to make women feel more welcome in tech' work? (2) What can we do when we see someone being excluded at work?	Lunch Box	Unwelcoming	"After a long morning on the road, Jim and I are starving. When we get to the site, this sandwich is going to hit the spot. He mocks me for eating healthy. Oh well, he only eats with the other guys anyway."
		Family Photo	Commonalities	"I carry a picture with me at all times in my wallet, so that I can look at my family and remember why I keep pushing on through adversity. Sometimes, I just need a reminder before hitting a 10-hour shift with the guys."
		Stepping Ladder	Judgement	"I need a stool or ladder to reach things, but I get this look from everyone like why is she even here if she needs that? But if the job is still getting done properly and efficiently, what does it matter if I need to reach things that most men don't."

2.2 Initial Research

In collaboration with a Canadian college (Algonquin College), we studied whether introducing a VR learning activity into a faculty workshop highlighting women's challenges in the trades could better engage faculty to create positive behaviour changes [2]. We used Circles [11], a social multi-platform VR learning framework, as it is web-

based, supports HMD, desktop, and mobile VR platforms, and uses symmetric selection-based interactions for greater accessibility [12].

We worked with the college's inclusion, trades, and journalism departments to conduct and analyze interviews with women in the trades, resulting in nine themes. These themes directed the design of three VLEs and nine VLAs, tied to personal narratives for better learner connection [16] (Table 1 and Fig. 1).

2.3 Pilot Studies

Researchers conducted exploratory pilot studies during a college donor event (pilot one), an educational conference (pilot two), and as part of a formal visual and search performance study (pilot three) [12]. Researchers set up all three VR platforms (desktop, tablet, and HMD) at a table for the first two pilot studies. They invited eventgoers to explore the electrician's lab VLE and VLAs (Fig. 1), and they did not guide eventgoers in any way except to answer questions about the experience and help with equipment. In the third pilot study, as part of a between-subjects empirical study into the selection and search performance of desktop, mobile, and HMD VR platforms, 45 users (18 women, 23 men, 3 non-binary, and 1 did not answer) between the ages of 18-44 (M = 26.93 years, SD = 7.64 years) with 15 participants assigned to each VR platform participated in a remote unguided exploration of the electrician's lab VLE [12].

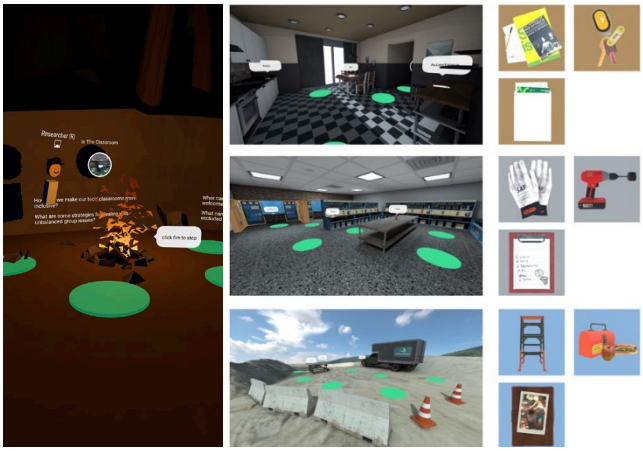

Fig. 1. Top left, the campfire for group reflection and connecting all VLEs. Top right, the "Growing Up" VLE with math homework, parents' shop keys, and acceptance letter VLAs. Middle-right, the "In the Classroom" VLE with safety gloves, drill, and instructor's clipboard VLAs. Bottom-right, the "On the Job" VLE, with stepping ladder, lunch box, and family photo VLAs.

During the first two pilot studies, researchers found that participants were uncomfortable using HMD VR technology around others in a professional context, following prior research on individuals hesitant to use emerging technology in public settings [17] and uninterested in exploring the desktop experience. In these settings, it was clear that participants preferred the tablet-based experience. We note that tablet VR allowed

participants to explore the VLEs and VLAs using a familiar semi-immersive device (as the device orientation adjusted their view of the VLE) and thus made it easier to communicate and connect with others while exploring the experience. These observations suggest that the social context of the gathering informed how participants use VR.

Researchers noted user experience (UX) challenges in the third pilot. Participants criticized the GUI's iconography as ambiguous and said it made selection difficult on smaller targets. However, researchers also received positive feedback on the selection-based locomotion (checkpoints) and VLA interactions. Participants noted that the VLEs are engaging, with VLE ambient sounds, narrative audio, and visual textures registered as highly immersive. Also, contrary to researcher observations in the public social gatherings of the first two pilot studies, participants reported that holding a tablet to interact was uncomfortable, tracking from previous research on using mid-air interactions [18].

3 Case Study

For our exploratory case study of social multi-platform VR in learning, we acknowledge that the critical study of real-world socio-cultural contexts when using educational technologies is necessary to understand the "state of the actual" [19, 20]. Following our exploratory pilot studies and development of the VLEs and VLAs, we recruited college trades faculty to participate in a workshop highlighting women's challenges in the trades. The workshop instructor utilized primarily traditional learning activities such as videos, discussions, and presentations. We developed the additional VR learning activity to increase workshop engagement and perspective-taking [8]. Our observations focused on how college faculty interacted and learned with VR as an embedded learning activity within a social learning space.

3.1 Participants

We used purposive sampling [21] and recruited 19 college trades faculty from a pool of 28 workshop participants who volunteered for the workshop and consented to have their data collected. However, only 14 participants (7 women, 6 men, and 1 preferred to self-describe) between 18-74 years (11 participants in the 34-64 age range) filled out the pre-study questionnaire. Each participant chose which VR platform to use to keep platform selection natural (10 chose desktop, 4 chose the HMD, and 1 chose tablet). All participants were moderately comfortable using technology. Only one had previously used an HMD VR device.

3.2 Apparatus

This workshop was remote-synchronous, using Zoom video-conferencing to connect with participants due to COVID-19 precautions. Each Meta Quest 1 HMD was sanitized and dropped off with each HMD participant. All desktop and tablet participants used their devices (Windows 10 PCs and an Apple iPad Pro 11").

3.3 Procedure

Workshop organizers used the VR content as an Inquiry-Based Learning (IBL) activity. Participants could discuss what they found within a campfire VLE with other participants. The workshop organizers encouraged reflection by re-introducing the introductory questions (Table 1) within the conceptualization stage to trigger the "disorienting dilemma" of transformative learning [7], in which the organizers challenge participants to consider the perspective of the tradeswoman narrating her challenges. They asked participants to discuss and reflect on the subject matter. Participants returned a second day a week later to present their experiences, conclusions, and potential transformation.

4 Results and Analysis

We captured qualitative data from participants in three forms. (1) open-ended questions from the post-experiment questionnaire, (2) informal post-experiment interviews where we discussed the experiment with participants when picking up borrowed equipment three to four days after the study, and (3) participant-observer notes from a researcher attending the workshop with the college faculty via a memo-style data collection.

We started with deductive codes such as inclusion, platform scalability, and social scalability from prior reviews [1]. For the inductive process, we followed an emergent coding approach. We determined nine themes during three rounds of identifying, merging, and sorting codes until thematic saturation was reached (Table 2).

Table 2. Starting with 11 deductive codes and adding 18 more inductive codes found by analyzing the qualitative data received, we settled upon 9 final themes.

Deductive Codes	# of Refs.	Inductive Codes	# of Refs.	Inductive Codes (cont.)	# of Refs.	Final Themes (after merging and sorting codes)
UX Challenges	20	UX Positive	3	Remote Learning	1	*Engaging Learning*
Accessibility	0	VR Ecosystem Challenges	10	Social Challenges	8	*Engaging VLEs*
Authentic Learning	8	Artefact Storytelling Positive	1	Social Request	1	*Engaging UX*
Embodiment	0	Artefacts Engaging	10	Technical Challenges	2	*Social Scalability*
Engaging Learning	12	Hub VE Positive	2	Unguided Challenges	6	*Platform Scalability*
Inclusion	1	Increased Discussion	5	Unsure of Learning	7	*Personalization*
Presence	3	Indifference	7	VEs Positive	5	*Skepticism*
Remembered Learning	7	Multiple VEs Positive	2	Water cooler effect*	1	*Internal and External Challenges*
Social Scalability	4	Novelty Positive	10	Personal Preferences Requested	13	*Transformative Learning*
Platform Scalability	2					
Transformative Learning	10					

**refers to the tendency of employees to gather around objects (e.g., a water cooler) to socialize and share information informally* [22].

4.1 Themes Identified from Participants' Data

Our analysis identified twenty-eight codes grouped into nine primary themes that overview using social multi-platform VR in a gender diversity workshop (Table 2).

Engaging Learning. We found that learning with VR appealed to most faculty workshop participants, often coupled with enthusiasm for using VR tools in their classrooms, e.g., *"Lots of potential with using VR here. I want to develop my content."*

Engaging VLEs. Workshop participants connected with the Circles' VLEs, noting that the VLEs helped with context, e.g., *"it helped me contextualize the issues visual in a setting,"* and that the VLA's woman narrator induced empathy for their challenges.

Engaging UX. Though not as strong a theme as "engaging learning" and "engaging VLEs," some participants enjoyed being able to move and interact with the space and VLAs, noting that it was *"very intuitive."* All participants could use the system with some guidance, but many desired a more intuitive VLA manipulation GUI.

Social Scalability. The Circles VR framework allows individuals to see and communicate with each other's avatars even when visiting different VLEs, and there were observations on how the unique social aspect was welcome, e.g., *"I liked seeing other people and what rooms they were in."* Some participants also used the campfire VLE to talk with others, creating a virtual water cooler effect. These observations suggest that "multi-world" interactions and reflection VLEs are valuable for community building.

Platform Scalability. Most chose to use desktop VR, which was more comfortable and familiar, but four did try HMD VR enthusiastically. However, switching to desktop VR from HMD VR within the workshop was crucial because some had issues with HMD, e.g., batteries running out. This flexibility of switching between platforms during VR learning activities is essential to allow for "situational" inclusivity [23].

Personalization. Participants wanted more control forms and objective-based learning activities (unlike the unguided IBL VR activity here). This feedback follows the pilot studies, where participants found mobile device interactions natural in social settings but uncomfortable in private settings.

Skepticism. Some skepticism took the form of uncertainty about the new technology, e.g., *"While the activity is interesting, words could have yielded the same result."* Others were indifferent to the material itself, even disagreeing with the context of the workshop, e.g., *"the artefacts had very little to do with the facts for me."*

Internal and External Challenges. Many of the challenges the workshop participants faced were surrounding the ecosystem, where the standalone Quest VR HMD required a Facebook account and phone to set up, or there were social challenges where some were unsure of how to interact with others. Additionally, there were UX challenges with the Circles framework. Some participants felt the button iconography was unclear

around VLA interaction and were uncomfortable with the VLAs occluding other objects within the VLE. Participants also found text challenging to read in the VR HMDs.

Transformative Learning. We found preliminary evidence for the transformation of worldviews [7] as "perspective-taking," e.g., *"I liked the use of worlds to help establish a better understanding of the person featured in the VR setting."*

4.2 Researcher Reflection and Discussion

This section will answer our three research questions and summarize our findings.

RQ1. What can we learn from the creation of VR VLEs and VLAs to guide future design and development for educators, developers, and researchers? We created the VLEs and VLAs with inclusion, creator (developers and journalists) members, and subject matter (women in trades) communities. The community-driven design process "based on a principle that the environment works better if the people affected by its changes are actively involved in its creation and management" [24] helped clearly define the VLEs and VLAs.

Challenges focused on content creation and usability issues. For example, running three pilot studies and including feedback from all communities is time-consuming, albeit worthwhile for greater authenticity. Overall, much of the experience was simplified using the Circles framework and its inherent platform and social scalability features [12], though some found the interactions GUI unclear. Further research is needed to facilitate better usability in designing VR learning content for multiple VR platforms.

RQ2. What are the challenges and opportunities in using desktop, mobile, and HMD VR to increase inclusion in VR learning activities? Our study demonstrated the ability of a multi-platform experience to increase engagement and inclusion. We observed high engagement when the VR experience incorporated immersive VLEs, intuitive UX, and authentic learning material. However, there are themes of "internal and external challenges" and general "skepticism" around using VR in learning. These challenges suggest we must also consider the socio-cultural aspects surrounding using VR tools in social learning spaces.

Having reflection spaces, e.g., the campfire VLE, to support processing, discussion, and reflection to create a virtual "water cooler effect" is a surprising but powerful observation. There appears to be a potentially large field of study into how parallel virtual worlds can create new and exciting social connections [1].

RQ3. 6. How do we connect how people create inclusive and engaging VR learning activities with how people use them? We refer to the usability of creating VR content as user experience (UX) and the usability of designing and developing VR content as creator experience (CX). Following, we describe the three primary continuums of outcome, people, and activity that make up a more effective VR model (Fig. 2):

- **Outcome** refers to the essential characteristics of the experience. Engagement and inclusion are the two most important outcomes of any VR learning experience, and they are interconnected as more inclusive experiences increase engagement.
- **People** are the groups involved in the VR experience. As noted by researchers [5], engaging with a community is more than the sum of individual engagements. A community, often described as people with a common goal, shared practices and traditions, and a sense of belonging [25], interacts with technology through different mechanisms [26]. Designers and developers consider individual and community levels in the People continuum when designing a VR experience.
- **Activity** refers to people's actions. A UX framework is required for designing inclusive and engaging VR learning activities. However, we also need a CX framework to make the design and development process inclusive and engaging.

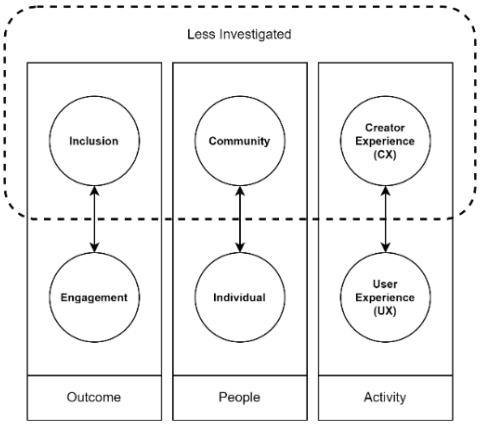

Fig. 2. In using VR in social learning spaces, we must consider the use and creation of VR content. We have inclusion and engagement as a continuum from the left, drawn from our user data. On the right, we have a continuum where a strong Creator Experience (CX) and User Experience (UX) are critical from our researcher observations. Finally, in the middle, we have a continuum where we must consider both the community and the individual in VR experiences. This theoretical extension results from our data and review of social learning spaces.

Our proposed holistic model identifies significant areas of further research by defining three continuums and two levels for each. Our research offers early insights into social learning spaces of post-secondary VR learning use, encouraging further research to explore expanded application into other social learning spaces and contexts.

4.3 Limitations and Future Directions

Our insights and the proposed model are from a relatively small exploratory body of work, including the workshop study, three pilot studies, and literature reviews within a rapidly evolving landscape. Please note that this exploratory case study's "who, where, when" boundary conditions (BC) [27] are post-secondary faculty in social learning

spaces during the COVID-19 pandemic. Additional real-world case studies using social multi-platform VR are required to understand better the many interconnected aspects of creating a transformative VR learning activity.

Additionally, CX requires further investigation [4], as our insights are grounded in limited observations of the co-design, development, and use of gender diversity VR.

5 Conclusion

We developed three VLEs and nine VLAs and studied user (UX) and creator (CX) experience in a multi-platform VR learning activity for a college's gender diversity workshop. Analyzing participants' data and our observations in their use within a learning workshop resulted in nine themes on social multi-platform VR use and insights into the community design process for VR learning. From this data, we proposed a model for social learning spaces that considers the outcome, people, and activity involved in creating and using VR learning to help inspire and direct future VR learning research.

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