CVRRICULUM Program: Benefits and Challenges of Embedding Virtual Reality as an Educational Medium in Undergraduate Curricula.

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Abstract

Since the release of more affordable, portable, and easy-to-use virtual reality (VR) systems in 2014, there has been renewed interest in using this technology in education, as an alternative to traditional learning, because it creates more opportunities for experiential education. Despite the many benefits and affordances of VR, widespread adoption in post-secondary education has been limited, and gaps remain in the provisioning of detailed guidelines for implementing this technology in curricula. Our team developed the CVRRICULUM (CVR) initiative: a pilot program that recruited instructors to adapt a traditional written assignment into a VR format. A mixed-methods approach was used to collect data from five instructor and 18 student participants. In this manuscript we describe the implementation process, report the identified challenges, and provide suggestions that should improve subsequent offerings. Our team addressed raised challenges by creating a set of resources available on the CVR website.

Keywords: Virtual Reality; Experiential Education; Nursing

1. Introduction

1.1. Background

Virtual reality (VR) has been used in aviation training for over half a century (Page, 2000), but for many years VR technology required costly resources, highly skilled technicians, and a large infrastructure footprint to function, limiting its wide adoption in education (Kavanagh et al., 2017). After a series of failed attempts by multiple tech companies to introduce VR into the commercial market, the field began to make headlines again in 2012 with the enormous success of the Oculus VR Kickstarter campaign, which led to the development of a wearable headset with stereoscopic displays providing the ultra-wide field of view (100-degree) needed to create the immersion promised by VR pundits decades earlier (Hussein & Nätterdal, 2015). Finally, in 2014 "Google Cardboard" was released, serving as a catalyst in the development and adoption of mobile VR (Boyles, 2017), with a number of other companies, such as HTC, Samsung, and Oculus, following suit and creating VR devices that are much smaller, more affordable, and easier to use, making them excellent tools for education more broadly.

1.2. Types of VR

To frame conversations around VR and its implementation in education, we must first provide a high-level understanding of the field and the various modalities, hardware, and software used, and acknowledge the differences between them. Although exact definitions of what constitutes VR differ in the literature, most describe a system of technologies that provide the user sensory information through, for example, visual, auditory, and tactile displays, and that offer varying degrees of immersiveness, but at minimum they provide a digital representation of a three-dimensional (3D) object and/or environment (Author et al., 2020). Two common distinctions across VR systems that have a critical impact on immersiveness are (1) how the virtual environments are created, and (2) whether devices are stand-alone or connected to multiple devices. Virtual environments can be created through either rendered graphics or live 360-degree video footage. While graphics allow for greater customization and ability for the user to interact and affect change in the virtual environment, these environments are more costly and complex to create, and depending on the skill level of the programming, may lack realism compared with 360-degree footage (which is regular live-action video captured in 360 degrees field of view). If we were to limit our discussion to wearable VR and exclude CAVE systems (immersive VR environments where images are projected onto three to six walls in a room-sized cube; Cruz-Neira et al., 1992), which are frequently used for clinical and research purposes, we could categorize hardware into two main kinds of systems: head-mounted displays (HMDs) that are tethered to an external computer (e.g., HTC Vive), and standalone HMDs (Oculus Go). Further, the sensors that track a user's motion and replicate their movement in the virtual environment can be either external to the HMD or built into the headset itself. Similarly, headphones built into headsets or external loudspeakers can generate spatialized binaural sound. Each of these modalities and respective devices has its benefits and costs, and selection should be based on the desired learning objectives and the resources available to support the implementation in education contexts.

1.3. VR in Education

Most educational applications of VR are found in post-secondary and graduate settings (Kavanagh et al., 2017). Hussein and Nätterdal (2015) report on students enrolled in a science course that used VR to visualize chemical reactions and systems in the human body, and to explore the solar system. Engineering students have used VR to watch animations of electrical machines to help them interpret electrical diagrams (Boyles, 2017). VR is perhaps most commonly used in medicine: for interpersonal training and learning to take medical histories from virtual patients instead of standardized patients, for visualizing internal organs from real-patient scans built into 3D simulations rather than cadavers (increasing the number of students who can learn from one patient), for using tactile and haptic affordances of VR technologies to improve the fine-motor skills needed for laparoscopies (Huber et al., 2015) and orthopaedic surgeries (Fang et al., 2014), and for getting used to high-stress environments like the operating room through 360-degree films complete with sound. Zackoff et al. (2019) studied the perspective of medical students on immersive VR in clinical training and found that the majority of participants reported a sense of presence and perceived VR as an effective alternative to traditional clinical training. This finding was consistent with those of Real et al. (2017), where learners perceived VR usage as equally effective as the use of standardized patients for clinical training. Moreover, due to the presence afforded by the devices, the system has been considered an effective tool for empathy training and building through exposure to multiple persons' perspectives (Ventura et al., 2020).

Another way VR technology has been used in pedagogy is through its application to distance learning. While remote and online course offerings have been steadily growing in popularity across post-secondary institutions, the global COVID-19 pandemic catapulted university investment in virtual learning (Allen & Barker, 2020). As just one recent example, in the wake of the pandemic, the Faculty of Science at Ryerson University in Toronto created an augmented reality (AR) remote education platform called RALE that includes real-time collaborative Zoom sessions with lab technicians and fellow student lab partners complemented by AR lab exercises that allow students to project into their home the lab materials required for each experiment (Grady, 2020).

1.4. VR Affordances

VR is considered a unique tool for teaching because it can replicate difficult-to-reach or otherwise impossible environments with high fidelity, for example, going into the past (Perez-Valle, Aguirrezabal, & Sagasti, 2012), going into the human body and understanding things on a biological level (Hayden, 2015), going into space (Hu-Au & Lee, 2017), and disaster preparedness. Learners are also able to practice their skills in a safe environment, as is the case with surgical skills training (Pulijala, et al., 2018)., and in many cases VR creates opportunities for experiential education when excursions or in-situ placements are hard to come by, as has been the case for nursing students needing to find hospital placements in order to complete their training (Smith, 2010; Jacobs, A. C. (2020). VR technology allows for control over exposure variables, thus providing the ability to adapt and customize a learning experience for an individual's skills and abilities (Abichandani et al., 2014). In this way, students can repeatedly try a task, and have factors increasing in complexity and difficulty as they master each phase, and educators can build in gamification applications in order to further motivate students to improve their abilities. For example, Smith et al. (2018) created a simulation of an emergency department room and featured a patient on a stretcher, where "players" (i.e., students) selected relevant tools (e.g., available personal protective equipment) and actions (e.g., remove patient's tainted clothing). Adding complexity to this scenario could include introducing competing interests (e.g., more than one patient) or disruptive environments (e.g., additional sounds). Perhaps most importantly, VR was found to be a means of enhanced engagement and immersion for students compared with traditional learning environments (Hu-Au & Lee, 2018).

1.5. VR Challenges

Despite these advantages, a recent systematic literature review on the topic of VR in pedagogy found substantial issues and limitations in implementing VR in education, many highlighting (1) the continued complexity of the programming required, and (2) the lack of "usefulness" or fit between the use of VR as a medium and the ability to reach learning objectives (Kavanagh et al., 2017). Nguyen et al. (2018) found that although VR is a good learning tool, when students lacked programming skills, they found projects challenging and reported having spent more time learning how to use VR than actually using it. From a teaching perspective, the lack of instruction for implementing VR in courses is a major limitation. Dunleavy, Dede, and Mitchell (2009) concluded that it is critical to understand existing effective instructional designs and to develop customized and outcome-specific assignments for better integration of VR/AR into education.

Based on these identified gaps and potential, our team developed and proposed to pilot the CVRRICULUM (CVR) initiative: a program that attempts to incorporate mobile VR technology into existing curricula and to evaluate its ability to create opportunities for experiential education and empathy building.

2. Research Questions

Primary RQ:

1. Is it possible to adapt an existing undergraduate curriculum assignment into one that employs VR?
    - What are the challenges?
    - What are the benefits?

Secondary RQ:

2. Is the VR medium an effective means of experiential education?
3. Is the VR medium suited for teaching empathy?

3. Methods

The CVR initiative was an attempt both to *implement a program* in existing curricula (applied project) and to *evaluate the program* and its pedagogical merit (theoretical contribution). In this manuscript we describe the protocol and results of implementation (related to RQ1). The secondary research questions are associated with the evaluation of the program and are described in a separate paper.

3.1. Equipment

The following VR equipment was used throughout this project: an Oculus Go VR Headset, a Yi 360° VR Camera, and a Bushman Panoramic Tripod. These devices were selected for their simplicity and their fidelity of experience. The Oculus Go was chosen for its relative affordability, its portability (mobile and wearable) and ease-of-use (stand-alone requiring no external hardware), and its built-in head tracking module, which greatly improves motion latency, reducing the chance that the user will experience simulator sickness caused by motion lag, often experienced with other, lower-end headsets like the Google

Cardboard. The Yi 360° is a small, lightweight VR camera equipped with two 180° lenses, capturing 4K 360° film; most importantly, it can automatically stitch internally without user input. Finally, the Bushman Panoramic Tripod is ideal for 360-degree film capture: it minimizes the footprint captured by the 360-degree cameras because the legs of the tripod extend only from the base of the stand, very low to the ground, allowing 360-degree panoramic photography and 360-degree VR videography. It was our goal to minimize the technical barriers identified as a main challenge by Kavanagh et al. (2017) and to focus on evaluating and providing suggestions for improved program implementation.

3.2. Program Implementation

Five course instructors were selected using purposive sampling based a one of the principal investigator's deep understanding of the course material. All five agreed to participate in the program, which involved (1) attending a faculty workshop, conducted in November 2019; and (2) recruiting from their third-/fourth-year courses in the upcoming semester. The faculty workshop was run by the two principal investigators and held on campus at a convenient time for all participants. The workshop taught faculty about VR and provided some basic instructions for using the equipment. As part of the resources for this workshop, the team created easy-to-use manuals for both the VR camera and the HDM. Time was also spent describing how the researchers envisioned the CVR program being implemented (discussing some course assignment examples), with the understanding that it was a pilot initiative and that elements would remain unknown until implementation. Finally, time was set aside to guide instructors through adapting a current assignment from their syllabus to a VR-based one that would maintain the expected course outcomes.

To support the faculty members in implementing the program, two research assistants (RAs; undergraduate students in digital media at the same institution) were hired and assigned as "navigators" for each course. The RAs were responsible for managing the lending of the equipment and for providing as little or a much hands-on help the student teams required. This flexibility was critical, as the assignments differed greatly, as did the skill levels of each student group.

3.3 Data Collection

A mixed-methods approach was initially approved (ethics approval was received from York University #: e2019–368) for evaluating the effectiveness of the program through pre/post questionnaires (administered in-class), anonymous student reflections (submitted online), structured observations from the RAs assigned to each student group (conducted when student groups interacted), and, at the conclusion of the program, focus groups with participating faculty and students (held virtually).

For details regarding the questions and instruments included the survey, question prompts provided to students for completing the online reflection, the structured observation guide used by RAs, or the interview and focus group script, as well as access to the complete transcribed data, contact the corresponding author.

3.4. Changes to Protocol due to COVID-19

The pandemic reached its height in March 2020, halfway through the semester in which this initiative took place, and as a result the university campus closed and courses moved to remote teaching; thus, many protocol changes to this study had to be implemented with little preparation. To begin with, further recruitment of student groups, which was expected to increase the sample size, was halted, and some existing groups that had begun their CVR projects reverted to traditional written assignments in order to limit additional "uncharted territory" work for instructors and students.

Although it was the intent to host focus groups with complete student teams, it was, first, difficult to reach all the students (few responded to our attempts to contact them via email) and, second, for those we were able to reach and who agreed to participate, it was difficult to find common time. Thus, the research team decided to adapt the focus group script to suit one-on-one interviews, lasting an average of 18 minutes. The research team still managed to conduct one focus group with the faculty participants, lasting 32 minutes. Both the focus group and the interviews were conducted remotely via Zoom video-conferencing software; students and faculty were awarded a $25 Amazon gift card for providing feedback about their experiences.

3.5. Data Analysis

The data collected from these four sources were qualitatively coded using grounded theory. The initial coding infrastructure was devised by one of the principal investigators through open-coding after the first reading of the data, and was refined and agreed upon by the research team. Six themes were identified, three of which (1. Necessary Resources, 2. Assignment Modification, and 3. Feedback about Technology) address program implementation, and three of which address program evaluation.

4. Results

All five faculty members who were approached about implementing the initiative agreed. These instructors attended a full-day workshop in November 2019 and provided quantitative and qualitative feedback in order to improve future training workshops. A detailed description of this workshop, its outcomes, and suggested improvements are found in a complementary paper.

Of the five instructors who attended the faculty workshop and agreed to the study, only four successfully implemented CVR in their courses. Although all instructors managed to adapt an assignment, one instructor was not successful in recruiting student participants. Of the courses that implemented CVR, three were third-/fourth-year nursing courses, and one was a third-year humanities course; a total of 19 students, divided into five groups, participated. The projects were diverse in topic (pain management, patient-centered care, cultural narratives), in style (from storytelling: acting out of a constructed script, to documentary style: capturing a cultural event live), and in the level of RA involvement. The group sizes, course representation, and RA involvement (from only providing technical support to helping ideate the project) are listed in Table 1. Figures 1 and 2 show groups of students together during a CVR work session. Student projects and final deliverables were presented to colleagues in class and uploaded to a private YouTube channel. Some projects can be viewed at CVRRICULUM Program/Examples. It is our team's intent to grow this "CVR" library to help instructors (1) understand what kinds of assignments can be adapted to VR, (2) recruit interested students, and, perhaps most importantly, (3) spread understanding and share experiences from completed CVR projects with students across different departments and faculties.

Table 1. Group size and RA involved by Course.

Course	Student group size	Degree of RA involvement
NURS 3514: Development of Self as Nurse: Nurse as Leader and Agent of Change	6	Technical support (camera setup, editing) Ideation
NURS 3524: Health and Healing: Client Centred Care of Individuals and Families in Child and Mental Health Settings	4	Technical support (camera setup, editing) Ideation
NURS 4546: Global Context of Nursing	2	Technical support
CLTR 3150: Doing Culture: Narratives of Cultural Production	GroupA: 4 people GroupB: 3 people	Technical support (camera setup)
HH/NURS 2522 6.00 Health and Healing: Client-Centred Care of Individuals with Common Health Challenges	No groups formed	No active support

Figure 1: Student tests the VR equipment to better understand how films look through the HMD

Figure 2: Student group practices their script before filming in VR

4.1. Qualitative Findings

Data from four anonymous reflections, 14 structured group observations, six one-on-one student interviews, and one focus group (including all five instructors) uncovered common experiences with program implementation. In this section, we describe and elaborate on these common themes (1. Necessary Resources, 2. Assignment Modification, 3. Feedback about Technology), providing qualitative excerpts from the various data collection methods representative of participant's feedback on each issue. Table 2 summarizes the themes and findings related to RQ1, and provides select quotations.

Table 2: Themes and select participant quotations identified through qualitative data analysis.

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Theme	Findings	Representative quotations from the data
(1) Necessary Resources	(a) Faculty workshop	"Missed part of the train-the-trainer workshop and didn't have session with [the RA] either so I had a hard time explaining it to my students"
	(b) Opportunity to experiment with technology	"A more practical opportunity to use the equipment would have been helpful and able to provide feedback to each other"
	(c) Technical support	"Without the "tech support" it won't happen"
		"They would not be able to get a good angle/use the VR alone, I don't think they would have gotten the best result. The tech support piece was very useful"
		"It helped having [the RA] but without him, it would've been hard implementing it within course curriculum"
		"Mentorship piece needs to be built into the mix"
		"Professors are not technologists so need hands-on tech support to enable implementation"
	(d) Previous CVR project examples	"RA came in with PI to articulate the project. It was after PI left, students were overwhelmed maybe it was because of the beginning of the project. First nobody wanted to do it but second time, got the 10% response rate. To recruit more, it might be helpful if PI comes in with a VR video example. Maybe it was foreign concept. So being more savvy in the recruitment strategy by showing applications would be helpful."
		"Not a lot of students came forward, a lot of them were overwhelmed. It would be a lot of work if they did a VR project so they opted to write a 4-page paper instead. The PI did a great presentation, it would be helpful to also showcase student work from previous year moving forward"
(2) Assignment Modification	(a) Value of assignment	"It was easier because no paper required but it was more time-consuming. Finding time to meet, record and edit required much more time. The assignment was only 5% and we put in hours meeting before class and after class. The effort we did was more intense than writing a paper."
		"Ideally, I would have liked to spend much more time learning about the technology and doing the video editing. However, the project was only worth 5% of the final grade, so my time was limited. The part that I enjoyed most was writing the script, and re-enacting the scenario. The part that I enjoyed least was being in a rush to finish with limited time available. I would definitely recommend that my friends participate in the VR project, especially if it was a large assignment."
		"15–20% is more reasonable than 5% for the amount of work you have to do"
	(b) Assignment clarity	"Students would have liked to have more information about the criteria for the assignment - what needs to be included in video vs the written part [in this case there was a reflection on the assignment to be submitted]."
		"the rubric given to students was formatted for the paper version of project not accounting for the VR hence generating some confusion. However everyone seemed understanding of the 'open format-ness' of the project due to its new technological nature."
		"students understand WHY they're doing this, in other words, what benefits or additional perspective VR brings to their learning experience. And that this in turn "can help them think about the assignment required and framing their video accordingly to highlight the "why".
		"Skill based rather than theoretical"
	(c) Sharing the project output	"it would have been more impactful to have groups present VR photo essay and discuss their experiences but didn't get to this final oral piece in class due to COVID"
		"COVID ruined the part where she could put on the headset and be immersed. Instead she had to look at the video which was more like 2d representation."
(3) Feedback about Technology	(a) Ease-of-use	"Students have begun using the equipment without any assistance. They can also troubleshoot simple errors (Bluetooth connection from phone to VR headset, and Bluetooth connection from phone to 360 camera)." Another reported: "Most students are eager to use the VR headset and 360 camera. No issues were present while students were using the equipment. Beyond the basic introduction, students seemed to be using the equipment almost intuitively."
		"the headset energy saving behaviour (turn off screen when not worn) confused some people as they would see prompts to recenter their screen and be unsure what to do - once everyone got comfortable with the headsets that was no longer a problem."
		"It wasn't so bad in terms of recording. The actual recording was straight forward but when it came to upload and editing, it was difficult. They did not know how to do it"
	(b) Capturing using a static-camera	"It was challenging to find the right moment to film (as it was documenting non-controlled action) as well as having all the group and RA stay out of frame to get clean recording."
	(c) Need for explicit consent	"It was challenging to find parts of the festival that can be recorded with not too many people all willing to sign the York video/photo consent forms."
		"Something to change is the access -- a specific area dedicated to VR projects on campus. Booking in advance for a room in a lab was a process. Maybe a dedicated area and resources like props for VR would be helpful."

4.1.1 Necessary Resources

Necessary Resources refers to elements that were essential to ensuring or that would be required in the future to ensure the success of such a program. The elements identified were mentioned at least once by all participating faculty and by some students.

The utility of the *Faculty Development Workshop (FDW)* was confirmed by all instructors. The one instructor was unable to attend the entire FDW or to schedule a private training session with an RA, admitted having great difficulty explaining the project and technology to her students.

While an important aspect of the FDW was the introduction to the devices, the opportunity to *experiment with technology* at greater length prior to the start of the course would prove beneficial**.** Although the participating instructors were given two months to try the camera and headsets before the start of the "recruiting" semester, they did not experiment with the technology, which may have affected their confidence in promoting the project and recruiting student groups. They reported several reasons, such as not having time to experiment, or its not being a priority, but only one reason can be actively addressed by the CVR team. Instructors expressed wanting more time with knowledgeable tech staff to experiment with the technology. They mentioned having insufficient understanding or training from the faculty workshop to be able to play with the equipment on their own. One instructor stated "A more practical opportunity to use the equipment would have been helpful and able to provide feedback to each other".

Similarly, while getting acquainted with the devices during the FDW was essential, the need for continued *Technical support* throughout the semester was raised. In this pilot we hired skilled graduate students to work as RAs alongside undergraduate student groups. This proved ideal, as graduate students were flexible in meeting with undergraduate teams and could relate to them; moreover, the experience provided them unexpected benefits, such as increased appreciation for different disciplines and the cross-pollination of skills-learning (described in greater detail in the complementary manuscript). It would be possible to provide technical support through other personnel, such as the university's IT department; however, this would mean losing the double-learning opportunity experienced by RAs (students themselves) and, further, might not be sustainable should the IT department lack the needed capacity.

Finally, having *previous CVR project examples* to share with faculty and students was mentioned as a clear way to garner interest in the program and increase recruitment. The use of novel technologies like VR in the classroom is still in its infancy, and one of the main goals of this initiative was to document the requirements for introducing VR into undergraduate curriculum and determining its potential scalability. Unfortunately, because of the initiative's novelty, the CVR team could not draw from previous examples of the project (that were similar to what we were trying to implement) in order to clarify the experiences and deliverables to instructors and students. It was therefore expected that we would receive the this feedback regarding providing previous examples, one instructor reflected, "not a lot of students came forward, a lot of them were overwhelmed. It would be a lot of work if they did a VR project so they opted to write a 4-page paper instead. The PI did a great presentation, it would be helpful to also showcase student work from previous year moving forward".

4.1.2 Assignment Modification

Assignment Modification refers to suggested changes to the CVR project to increase recruitment and to ensure greater success of the program.

The CVR project proved to be time-consuming; therefore, it was suggested to increase the *value of assignments***.** As this was a pilot study, we lacked precedent for how much effort would be required to complete the student projects. We also wanted to give faculty the greatest flexibility in incorporating CVR into their existing curriculum. Thus, instructors were allowed to choose an existing assignment, and the respective credit value of that assignment, within their course. Most instructors elected to replace a 5% assignment with the CVR, which proved to be too little given the time students spent to complete the project. One student reflected: “It was easier because no paper required but it was more time-consuming. Finding time to meet, record and edit required much more time. The assignment was only 5% and we put in hours meeting before class and after class. The effort we did was more intense than writing a paper.”

Assignment clarity refers to mentions by faculty or student participants addressing the need for greater definition and description of the steps to be undertaken and expected output of the CVR project. Similar to the challenge of assigning an appropriate value to the assignment, the CVR team had no existing experience to draw from in terms of assignment rubrics and wanted to allow for flexibility to adapt assignments to each course and instructor. This meant that what was expected of students remained vague. One instructor remarked, “Students would have liked to have more information about the criteria for the assignment - what needs to be included in video vs the written part [in this case there was a reflection on the assignment to be submitted].” While there was an attempt to create a specific rubric with deliverables for the CVR project (this was initially a goal of the faculty workshop), we found that many instructors simply used the same grading metric for CVR submission that they used for their traditional written assignments. A participating instructor suggested that we ensure “students understand WHY they’re doing this “in other words, what benefits or additional perspective VR brings to their learning experience. And that this in turn “can help them think about the assignment required and framing their video accordingly to highlight the “why. The CVR team admits a shortcoming in this regard; while the immersive and empathetic nature of VR was well defined in the project proposal, the “benefits” were lost along the way, and the underlying motivation was not conveyed to students during the recruitment phase. There was some agreement among the instructors that skills-based rather than theoretical courses would be better suited to CVR but others also noted that having gone through it once, and with greater understanding of the process and output, they can better create opportunities for implementation in different courses. “I believe I have a better idea of the project now than I did earlier so now I can plan a better project, get more buy-in from the class and think of a lot more great projects”.

Finally, *sharing the project output* was mentioned as an important facet of the assignment. While the ability to do this during the pilot was impacted by the COVID-19 pandemic, the issues mentioned are still relevant when designing assignment criteria in order to ensure success in future iterations of the CVR program. Instructors suggested that *presenting back to the class* be a mandatory part of the assignment, and preferably that it be *viewed through the VR headset* in order to take full advantage of the medium. A general misunderstanding was the ability to share and experience the *projects online*. As part of the project, the CVR team had created a private YouTube page to house all the student projects. Output from each completed project was uploaded to the website by an RA; however, this was not properly or sufficiently communicated to instructors.

4.1.3 Feedback about Technology

Feedback about Technology refers to any mention of the ease or difficulty in learning to use the VR camera or headset, applying it to the assignment, and sharing it with others.

Ease-of-use of these novel devices was of initial concern for both the CVR team, and instructors however, feedback revealed that most students were comfortable operating the equipment and found the technology familiar to other information communication technologies they use in their everyday lives. RAs noted, “Most students are eager to use the VR headset and 360 camera. No issues were present while students were using the equipment. Beyond the basic introduction, students seemed to be using the equipment almost intuitively.” Even when some aspects were not as intuitive, with some practice, it appeared that students were able to learn quickly: “the headset energy saving behaviour (turn off screen when not worn) confused some people as they would see prompts to recenter their screen and be unsure what to do - once everyone got comfortable with the headsets that was no longer a problem.” It is worth noting that the Yi-360 VR camera appeared easier to use than the Oculus VR headset, and that much of the technical difficulty revolved around downloading and uploading the films to the different devices. There were also some reported challenges in connecting the Oculus GO headset to iPhone devices, a common problem when Android and iOS devices need to communicate using different protocols. The RAs said that it was a significant effort to get all the groups up and running, but that initial challenge was not related to the devices themselves but rather organizing students’ schedules to train them to use the equipment.

A limitation of the technology mentioned by one group was the *difficulty in capturing a dynamic environment with a static camera*, supported by a tripod. One student said, “It was challenging to find the right moment to film (as it was documenting non-controlled action) as well as having all the group and RA stay out of frame to get clean recording.” While the Yi camera does make it possible to capture live action, in 360 degrees, moving the lenses in space while filming would not result in a good experience, and so this limits the kinds of action and environment that are best suited. These aspects were described to faculty in their workshop but were likely not conveyed properly to students when they were designing their assignments. Other VR cameras are better suited to capturing during movement, but they are also more expensive and complex to use.

Another identified challenge related to the technology was the *need for explicit consent* for individuals who were captured on film. “It was challenging to find parts of the festival that can be recorded with not too many people all willing to sign the York video/photo consent forms.” recalled one student. Instructors and some students expressed concern about the privacy and confidentiality of individuals recorded, and the difficulty of excluding people who did not provide consent (or for whom consent was not possible to obtain) given the 360-degree capture of the frame. The notion of consent and privacy was covered in the faculty workshop but again could have been more explicitly described to students and accompanied by tips on obtaining proper consent or on designing a recording that would not require explicit consent. One student suggested that to overcome these challenges, the university should offer dedicated recording space: “Something to change is the access -- a specific area dedicated to VR projects on campus. Booking in advance for a room in a lab was a process. Maybe a dedicated area and resources like props for VR would be helpful.” While this can be a useful resource for student groups creating their own narratives and scripts, it would still leave those “documentary” projects that capture in-situ events with the need to properly understand, respect, and collect explicit consent.

5. Discussion

In the next section we address each of the issues and suggestions raised by faculty and students and describe changes we have already made to ensure the success of the CVR program and the ability to scale to additional courses across campus. Most of these challenges were surmounted by creating additional resources compiled into three documents: (1) Instructor’s Guide, (2) Student workbook, and (3) Equipment Manual, all available for download from the CVR program website (https://www.yorku.ca/cvrprogram).

5.1 Necessary Resources

The most frequently reported critical resource was the support, both technical and sometimes conceptual, provided by the RAs. For the pilot year of this project, the university provided funding to support hiring Ras; this, however, cannot be guaranteed moving forward. Given the immense learning experience and benefits described by our RAs, we suggest that the CVR initiative be a partnership between two courses. One instructor from an undergraduate course (adapting a traditional assignment and providing their students an opportunity to complete a CVR deliverable) would partner with an instructor in a graduate-level media studies course (graduate students volunteering to help an undergraduate team for course credit). Given the intensity of the technical support provided by RAs, we suggest that graduate students earn at least 20% of their course credit by participating in this initiative. As instructors from these distinct disciplines may not know one another, or may not know of one another’s interest in participating in such an initiative, the CVR team would create a list of interested instructors across campus and share this list at the FDW as well as online on the project website. In addition, the team has created a number of complementary resources that provide step-by-step instruction in how to manage technical aspects of the project that were previously not described. We now have a detailed guide for using the VR camera, headset, and tripod; for uploading/downloading content to other devices, and for sharing content online. Content for this resource was also heavily informed by technical challenges described by instructor and student participants and observed by RAs. In the future, we can consider creating an instructional video to complement the guide.

It was apparent from feedback given directly after the faculty workshop, and then reiterated during the focus group at the conclusion of the project, that the faculty workshop was incredibly beneficial. The CVR team suggests that such a training workshop be held at least once a year to help onboard new interested instructors, and to reach a larger audience (that may not be able to attend in person) to allow others to join remotely via web conferencing (Peisachovich et al., 2020). In the future, we suggest splitting the faculty workshop over two days, perhaps one week apart, where participating instructors are given “homework” to record using the VR camera and present back to their colleagues the following week. This will not only ensure that instructors have the opportunity to experiment themselves with the VR equipment but also highlight to the CVR team areas that need additional explanation and training. Furthermore, the act of completing a filming themselves may spark project ideas that instructors had not previously considered for their courses.

Finally, while it was not possible to share previous project examples during the pilot year, the CVR team now has at least four completed assignments, with consent to share in future years with interested instructors and students. Although the initial FDW was recorded, edited, and posted online, it would be beneficial to re-record and share future faculty workshops, as they will incorporate and address feedback given by previous participants (e.g., include updated information, refined descriptions of the tools and protocols, examples from previous semesters). We also intend to create a document with common Q&As from previous sessions that will be available on the project website.

5.2 Assignment Modification

The second common theme that emerged from participant feedback was the need to modify aspects of the assignment. An important suggestion was to increase the scope of the project and the assignment weight to reflect the time required to learn and complete a CVR assignment. This would give students more time and incentive to dive deeper into VR learning and applications. After consultation with the participants, it would seem that the project should be valued between 15% and 20% of the final course grade. This information is critical to share with instructors planning to integrate the study and adapt existing assignments into a CVR deliverable. Instructors should either select assignments that carry that weight and have them adapted, or create entirely new assignments that have a matching “traditional” component worth the same percentage. Assignment clarity, or lack thereof, is a frequent criticism students raise even with traditional assignments. Given that there were no previous examples, and that the goal was to leave the adaptation of the assignments to individual instructors from diverse courses, it was expected that there would be vagueness around what is expected of students; instructors and students alike reported understanding the need for flexibility given that this was the pilot year. In the future we will address this challenge by providing example projects, together with assignment descriptions and suggested grading rubrics, as part of the how-to guidebook for participating faculty at the FDW. We will also place greater importance on completing a draft assignment description by the end of the FDW so that there is sufficient time to receive feedback from participating colleagues and the CVR team before the course start date. Of note, one instructor reported liking placing the onus of adapting the assignment on the student. We believe this could be best integrated if the CVR program were available for graduate courses (where greater initiative could be expected of students) or perhaps an opportunity were created to design a student-initiated individual project course, whereby an interested student can propose a CVR project to faculty member and can borrow equipment through the library.

Irrespective of delivery method, this pilot has highlighted several aspects that could help ensure successful design and completion of a CVR program. In order to help students, the CVR team created a modifiable workbook (template) that includes suggestions for incremental deliverables and goals to ensure that the project moves forward and adheres to necessary timelines. This workbook will be included among the resources provided to instructors at the FDW so that they can adapt and share with their students, as well as online at the project website. One aspect faculty raised was the need to share the output back with the class, preferably through the VR HMD, as that provides the most immersive experience. This recommendation is now highlighted as the final goal in the workbook and provides clear instruction for sharing the “VR film” online, in VR.

5.3 Feedback about Technology

Each of the technical challenges (e.g., how to best prepare a dynamic scenario to be captured by a static camera, how to effectively plan to obtain consent) creates an opportunity for learning. In order to support this kind of learning, the team added content to the supporting documents that includes tips for thinking through appropriate venues (Instructor guide/ Student workbook), and lighting and sound implications for filming in 360 degrees (Equipment Manual). Equally important, the student workbook should outline the potential difficulties around obtaining consent and encourage students to think through and formulate alternatives and solutions ahead of facing problematic situations (e.g., include scenarios where consent has to be taken from multiple people at a public event). We expect that the more common challenges around using the technology are likely to fade with experience using the equipment.

6. Limitations

While outcomes of the CVR program are promising and paint a bright future for the implementation of VR in higher education, it should be noted that recruitment for this initiative was predominantly undertaken by one specialty, nursing. Further, a purposive sampling strategy was employed and reached only a small number of eager faculty. In the future, the initiative should be explored across a larger and more diverse set of courses and students. The COVID-19 pandemic and the unexpected shifting of in-person, on-campus university courses to remote learning had a critical impact on the completion of the project and required significant adaptations to the project evaluation methodology.

7. Conclusion

Despite the inevitable challenges introduced by the COVID-19 pandemic, we were able to draw interesting conclusions about the feasibility and effectiveness of the CVR program and suggest some improvements that would make the initiative sustainable and scalable in the future. This pilot proved that it is possible to incorporate VR into an existing undergraduate course, even with little preparation and minimal faculty training. The findings from our evaluation identified issues and brought specific suggestions around necessary resources, such as technical support, assignment clarity, such as appropriate grade weight/value; and technical feedback, such as specific challenges around obtaining consent. The CVR team has addressed these concerns by creating additional project resources compiled into three documents, a how-to Instructor guide, a step-by-step Student workbook, and an updated and extended Equipment manual. Furthermore, the ability to now share completed assignments (generated from this pilot) will be extremely helpful to future participants in envisioning how VR can be implemented in diverse curricula and adapted to their specific learning objectives. The compiled resources will be made available on our CVR program website (https://www.yorku.ca/cvrprogram), and our team will continue to report on the results and feedback provided in subsequent implementations of the CVRRICULUM initiative.

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