

Students' Experience with a Virtual Reality Tool:

Brain Stories

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Abstract

Virtual Reality (VR) has been applied at the higher education level to teach students about a variety of topics. This paper documents the experiences of higher education students with a VR tool, Brain Stories, as part of quality improvement funded by an IDEAWORKS Catalyst Fund grant. This tool introduced students to fictional characters diagnosed with a brain disorder: Aaron with autism, Henry with schizophrenia and Linda with Alzheimer's disease. This tool was introduced to build interest in learning while developing empathy through the first-person perspective used with characters. In total, 41 students (2 male; 39 female) provided feedback about their experiences. When asked if they would recommend this tool, 31 students (84%) said "yes". A qualitative analysis of students' responses revealed the following themes: Contribution to Learning, Person-Centered Perspective, Immersive Experience, and Suggestions for Improvement. Recommendations are provided for how VR can be incorporated in future postsecondary classrooms in accordance with Universal Design for Learning principles and the development of a Community of Practice.

Keywords: Higher Education; Virtual Reality; Quality Improvement, Qualitative Themes; Descriptive Statistics

Introduction

Virtual Reality (VR) involves 3-D computer graphics that are used with interface devices (Madathil, 2017). Users can experience VR in two ways: desktop, which uses a personal computer to expose users to 3-D multimedia simulations and immersive, which provides a portable environment through head-mounted displays (Madathil, 2017).

Immersive VR is becoming more popular and affordable with the increased accessibility of head-mounted displays to the consumer market (Hollander, 2018). This accessibility makes VR more likely to be incorporated into educational settings thereby creating a community of practice (CoP). According to Musteen, Curran, Arroiteia, Ripollés, and Blesa (2018), CoP is a "collaborative approach to learning, and through practice, facilitating both knowledge sharing and creation within a specific domain" (p. 1). This knowledge sharing is critical given many educators acknowledged feeling they were learning alongside their students (Castaneda & Pacampara, 2016). Having a CoP may therefore, address this potential gap in knowledge on the part of educators while helping to alleviate concerns they may have over the expertise required to incorporate VR into the classroom.

VR has been applied at the higher education level to teach students about a variety of topics including the environment (Turk, Kalkan, & Yildirim, 2017), astronomy (Maher et al., 2016), foreign language learning (Ochoa-Alpala & Ortiz-Garcia, 2018), and even perspective-taking on topics related to racial discrimination (Reinsmith-Jones, Kibbe, Crayton, & Campbell, 2015). In a study conducted by Yildirim, Mehmet and Yildirim (2018), wherein VR was used to teach about ancient civilizations, one student described the benefits of this technology: "...Egyptian Pyramids are in one of the Seven Wonders of the World but how much opportunity do we have to go and see those...if Ancient Pyramids

are shown with VR technologies, I can visit those places...I can learn information" (p. 67). Provided with the opportunity to explore virtual worlds at their own pace, students often reported developing important soft skills related to time management: "Because you can reach that environment anytime and from anywhere it is definitely positive, especially in individualized learning..." (Can & Simsek, 2015, p. 121). Furthermore, the ability to practice and manipulate objects allowed VR to be a natural fit with some academic disciplines, for example, engineering, where one student described using this technology for product dissection: "When you do it physically, you have different pieces lying on the table and you have to do it step by step, but with this, you could easily see how every piece had its own role in the assembly" (Toh, Miller, & Simpson, 2015, p. 65).

Although VR has the potential to teach important skills, not all of the research in this area has been favourable. As an example, a study of undergraduate students at Cornell University found when learning about moon phases, students reported being more engaged but not actually learning more when VR was used over other teaching methods (Madden et al., 2018). VR might pique the interest of students and enhance their motivation to learn about a topic; however, it does not necessarily lead to improved performance on assessments of learning outcomes, when used over other teaching methods. This and other research provides us with an opportunity to understand not only how to use this technology in classrooms, but also the conditions in which this technology is most likely to have the greatest benefit to students.

Simultaneous improvements in student learning and engagement may occur, in part, when both technology-based as well as student-based factors are considered in VR. According to a recent systematic review about students' experiences with VR in higher education, student-based factors involved

understanding how comfortable the learners were with this technology as well as how their academic background could potentially affect their experience (DePape, Barnes, & Petryschuk, 2019). Likewise, Yildirim et al. (2018) reported that a lack of experience with this technology could be a barrier to adoption as described by the following student: "I do not know, maybe, it is because I used it the first time but I found it scary" (p. 65). In terms of technology-based factors, it was found that usability and high quality graphics ranked high (e.g., Bahng & Lee, 2017; Toh et al., 2015), while at the same time students expressed that they wanted this technology to be placed into a learning context (e.g., Bahng & Lee, 2017; Chien et al., 2013). This context served to scaffold learning while preventing students from simply seeing the technology as a form of edutainment (e.g., Alizadeh et al., 2017) or something that was not worth pursuing as described in the following: "I would have much preferred doing a report" (Nadolny et al., 2013, p. 991).

The idea of scaffolding was introduced by Lev Vygotsky as part of his sociocultural theory whereby experts tailor the support provided to learners, with more support provided in the early stages of learning (Shaffer et al., 2010). This support is gradually reduced over time so that learners can increase their understanding of the task and, in turn, their ability to complete such tasks on their own (Shaffer et al., 2010). In the case of VR, scaffolding learning implies that this technology does not replace traditional teaching methods, but instead, can enhance learning, especially when structured around the learning objectives of a given course.

The Current Study

The first author received an IDEAWORKS Catalyst Fund, which was awarded in the category of Scholarship of Teaching and Learning. Specifically, this funding aims to improve student learning and educational quality by "designing a course,

facilitating classroom activities, trying out new pedagogical ideas, writing student learning outcomes and evaluating programs" (IDEAWORKS, 2019, p. 2). This internal funding offered by Mohawk College of up to \$12,000 CDN to faculty is for short-term projects (1 year) that may stimulate future research in education. Given the department already had access to VR headsets (Google Cardboard, <https://vr.google.com/cardboard/>), this funding was requested to develop a student-centered VR tool.

The current study incorporates VR into the course, Brain, Mind and Memory, which is part of a 1-year graduate certificate program, Brain Disorders Management at Mohawk College. This course was selected for this project given the case study approach used, which is also reflected in the VR tool we developed. Specifically, this 2-hour in-class course for 14 weeks examines a series of case studies featured in the required text, *The Brain That Changes Itself* by Norman Doidge. This text examines the lived experiences of Cheryl Schiltz, Barbara Arrowsmith Young and Michael Bernstein, to name a few, who have suffered a brain injury or disease and retrained their brain through cognitive and physical therapy.

The Brain Disorders Management program is part of the Department of Community Studies, which has largely been under-represented in the literature in terms of its use of VR (DePape et al., 2019). This department at the higher education level often includes programs that are concerned with human welfare, such as Child and Youth Care, Early Childhood Education, Autism and Behavioural Science, and Developmental Service Worker. As such, there is a need for students in the Brain Disorders Management program to be proficient in the theory associated with a variety of human conditions as well as display appropriate prosocial emotions, such as empathy in relation to these conditions.

This study documents the experiences of higher education students with a VR tool called Brain Stories, which was developed by the first author in collaboration with a software developer to achieve two objectives. First, introduce students to three fictional characters: Aaron, Henry and Linda who have been diagnosed with autism, schizophrenia and Alzheimer's disease, respectively. Second, determine whether the case study approach using a first-person perspective will pique an interest among students while fostering prosocial emotions, such as empathy.

This tool serves to introduce students to brain disorders, which include conditions caused by illness, genetics or traumatic injury (Healthline Media, 2019). This tool also introduces students to brain anatomy before learning more about the implications of these conditions later in the semester. These brain disorders were selected given their prevalence with 1 in 68 diagnosed with autism (Christensen et al., 2016) while the number of people with Alzheimer's disease is expected to more than double by 2031 (Alzheimer Society of Canada, 2018). Although schizophrenia affects about 1 percent of the population (Statistics Canada, 2015), the severity of this condition leads many students to fear mental illness and harbour misconceptions that are potentially harmful to their learning.

With respect to prosocial emotions and VR, much of the research to date has focused on students in health sciences who were exposed to virtual worlds and patient simulations (Ausburn et al., 2009; Benham-Hutchins & Lall, 2015; Keskitalo, 2012). Our project will contribute to this growing literature using a community studies lens and identify whether a case study approach using fictional characters is a good fit with this technology. This project also aligns with the five-year strategic planning at Mohawk College to produce "future ready" graduates, with simulated, experiential learning opportunities being a top priority (Mohawk College, 2016a, p. 3).

Design and Methods

Participants

Students in the graduate certificate program, Brain Disorders Management at Mohawk College in Hamilton, Canada were selected to provide feedback about Brain Stories as part of a study supported by an IDEAWORKS Catalyst Fund grant. Before funding was released, the first author was required to contact the Research Ethics Board (REB) at Mohawk College to determine if the project, funded through the category of Scholarship of Teaching and Learning, required ethics approval. After consultation with the REB Committee, it was deemed the project aligned as quality improvement instead of a research study (Henderson, 2018). One key distinction between quality improvement and research is that the primary purpose of the former is to enhance internal processes whereas that of the latter is to generate new knowledge that can be generalized to the larger population (Fraser Health, 2014).

The Brain Disorders Management program accepted its first student cohort in Fall 2017. This program is the first of its kind in the province of Ontario, Canada and makes use of varied teaching methods including traditional lectures, guest speakers, field trips and patient simulations. It was therefore deemed a good test subject for this project. In this academic program, students learn about a variety of conditions in their first semester including autism, schizophrenia and Alzheimer's disease. Instead of simply telling students what they will learn, it was believed VR could be introduced into the curriculum to provide a high-level overview of topics before delving into more detail in the semester. VR would therefore serve as a learning hook by building interest about the material to be learned and thereby, provide an opportunity for quality improvement.

Mixed Methods Approach

Quality improvement allows descriptive statistics to be examined in order to identify trends in the sample data (Fraser Health, 2014). Combining these statistics with qualitative data as part of a mixed methods approach, further allowed us to understand how to incorporate VR at the higher education level. Specifically, descriptive statistics were used to create a profile of learners including demographic and background information. Qualitative themes were identified in order to provide a rich context in which to understand the experiences of students with the VR tool.

Out of 58 students, 41 participated in this project with demographic information summarized in Table 1.

Table 1. Demographic Information

Sample Characteristics	
Age	M = 25.5 years
Gender	Males = 2; Females = 39
English as First Language	Yes = 29; No = 12
Languages Spoken Besides English	Punjabi, Urdu, Bengali, Arabic, Hindi, Portuguese, Gujarati, Spanish, Tamil, Polish

Apparatus

According to Mohawk College's Purchasing Policy, "all procurements relating to goods and non-consulting services shall be competitive when the total value of the procurement is \$100,000 or above" (Mohawk College, 2016b, p. 3). Given that the IDEAWORKS Catalyst Fund is below this amount, the first author compiled a list of software developers through an Internet search that were

within driving distance to Mohawk College and had previous experience with VR in educational settings.

Three software developers were contacted by the first author who shared information about the project and requested a quote. All quotes were reviewed by the first author in collaboration with her direct supervisor, the Associate Dean of Community Studies. Of the three companies, Shain Michael Design (Toronto, Canada) was selected based on the ability to work one on one with the first author while coming within the approved budget and timeline set by the grant. All authors of this project along with the Associate Dean did not personally know the staff at Shain Michael Design before this project or have a previous working relationship with this company.

The first author in collaboration with a faculty member in Community Studies created a script for the VR tool. This faculty member has a PhD in Medical Neuroscience and acted as a content expert in developing the curriculum for the Brain Disorders Management program. This consultation with faculty ensured that the content involved in the VR tool was consistent with the curriculum in the program while building on required readings that involved textbooks and peer-reviewed journal articles. This consultation also allowed for an iterative process whereby the content was reviewed, discussed and revised accordingly.

For each brain disorder, a description was provided about its core symptoms, such as impaired social functioning, and repetitive and restrictive interests as part of the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM-5; American Psychiatric Association) criteria for autism spectrum disorders (ASD). For each condition, a part of the brain was highlighted so that the behaviour of this character was placed into context. For example, in the case of Aaron who had autism, students learned that this condition is characterized by early

accelerated brain growth (Courchesne, 2004), which leads to reduced long-range connectivity and increased short-range connectivity (Courchesne & Pierce, 2005; Just et al., 2004). The result is a brain that communicates more heavily within brain areas instead of across brain areas, making speech difficult to understand given the need to integrate what is seen and heard. Finally, for each disorder a practical implication was offered so that students understood what it may be like for an individual to have this condition, which was part of the empathy evoking quality of our tool. In the case of Aaron, students learned how at school, his teacher often thought he was misbehaving. However, in reality, Aaron had trouble understanding speech given issues with audio-visual integration.

After the script was completed, Shain Michael Design developed a storyboard that provided a high-level view of the VR tool. Stock photos were selected for the characters of Aaron, Henry and Linda along with 3-D images that provided the basis for the brain model. Voice actors were also recruited by Shain Michael Design to play Aaron who was an adolescent, Henry who was a young adult and Linda who was an older adult; all of the characters had Canadian accents. One challenge experienced in the selection of actors was finding individuals who accurately reflected the age of these characters through their voice while being able to correctly pronounce the scientific terms as part of the script. This challenge led to multiple recordings being made, particularly for the fictional case of Aaron who was an adolescent.

Once the graphics and audio were complete, Shain Michael Design uploaded a copy of the VR tool in the form of a high-definition 360-degree video to a secure channel on YouTube. The first author reviewed the video and Shain Michael Design revised the video accordingly, based on the feedback received. Finally, the first author and Shain Michael Design put together instructions that could be shared with students on how to use the VR tool.

Procedure

In the first week of class, students in the Brain, Mind and Memory course were informed by the first author about the opportunity to provide feedback about Brain Stories. Specifically, in their course syllabus, this opportunity was listed as part of their regular class in Week 3 of the semester. This point in the semester was selected so that students had time to settle into the program but had not yet received any lectures about autism, schizophrenia or Alzheimer's disease.

A week before Brain Stories was introduced, students were reminded about this opportunity on eLearn, which is the learning management system for their course. Students were asked to bring their cell phone to class, fully charged with the YouTube app downloaded, along with a pair of headphones.

On the day Brain Stories was introduced, the first author provided an overview of the quality improvement project. Specifically, students were told that the Brain Disorders Management program was interested in incorporating VR into its curriculum and needed feedback from its students. They were told to provide this feedback in the context of Brain Stories, which could be introduced as part of the curriculum to future student cohorts.

Students were told not to include their name on any forms associated with the project as the first author was interested in the overarching themes about their experience. Students started the project by accessing the YouTube link for the VR tool via their cell phone. They then connected their headphones to their cell phone and placed their cell phone into a headset, Google cardboard (<https://vr.google.com/cardboard/>), which allowed them to experience VR. Any questions or technical issues experienced by the students were addressed by the

third and fourth authors who were graduates of Mohawk College and served as volunteers for this project.

The VR tool lasted for approximately 5 minutes and students experienced the tool in the same order, starting with the story of Aaron, Henry and then Linda. This order mapped onto lifespan development with Linda having the highest chronological age of all characters. Students had the option of pausing or replaying the tool after they had experienced it for the first time. Finally, students completed a questionnaire that involved 27 questions. This questionnaire collected demographic and background data along with information about their likes, dislikes and recommendations about Brain Stories. This questionnaire took approximately 30 minutes to complete.

Results

Quantitative Data

Due to missing data, 4 students were excluded from analysis reducing the sample size to 37. There were 20 questions that involved quantitative responses on our user experience questionnaire.

In terms of online coursework, nearly all students (93%) reported they had taken at least one course at the higher education level that was delivered fully online.

Students also reported their typical daily usage of various technological devices. The median score among students for phone use was between the 1-5 hour and 6-10 hour categories (46% and 30% respectively), laptop use was 1-5 hours (59%), tablets was 0 hours (78%), and desktop computers was 0 hours (78%). Given that response categories cover a range, it was not possible to sum these values in a meaningful way.

When asked about their previous experience with video games, 32% of students indicated they had no or limited experience, 42% indicated they had moderate experience and 24% indicated they were proficient or experts with video games. The majority of students (89%) indicated they had no or limited experience with VR and only 11% indicated they had moderate experience.

When asked if they would recommend this VR tool to other students, 31 students (84%) said yes. Several demographics were common among those who did not recommend the tool. Some of these included being female (100%), having taken online courses (100%), and speaking English as a first language (83%). Interestingly, a greater proportion of the students who did not recommend the tool indicated they had proficient or expert knowledge of the brain (67%) and knowledge of brain disorders (83%) when compared to the rest of the sample (61% and 66% respectively).

Qualitative Data

There were 7 questions that involved qualitative responses on our user experience questionnaire. Key themes in the data were identified using thematic analysis. Previous literature using thematic analysis has been criticized for failing to be clear and explicit when outlining the methodology. To avoid this pitfall, methods for producing the thematic analysis are based on the phases outlined by Braun and Clarke (2006): (1) familiarize yourself with the data; (2) create codes for the data; (3) search themes; (4) review and refine themes; (5) finalize and label themes; and (6) write and disseminate findings. Themes were identified inductively: data were read and coded without any preconceptions, allowing the data to form the themes. Themes were repeatedly reviewed and refined to ensure coherent patterns within and across the data. Direct narratives were used to illustrate each theme and its prevalence in the data.

During the analytic process, consensual qualitative research strategies (Hill, Thompson, & Williams, 1997) and "investigator triangulation" were used (Carter, Bryant-Lukosius, DiCenso, Blythe, & Neville, 2015). The first and third authors worked collaboratively to code the data and resolved discrepancies through discussion. The second author who was not affiliated with Mohawk College and therefore, at arm's length with the project, audited the analytic process and provided a final check on the categorization and thematization of data.

Through the use of thematic analysis, key impressions of the VR tool were identified. Themes reflected the feedback of all students and provided a glimpse at responsiveness to the tool in the classroom. The themes were: *Contribution to Learning, Person-Centered Perspective, Immersive Experience, and Suggestions for Improvement*. The range of response valence is highlighted within and across themes. Representative quotations by themes are provided in Table 2. Each participant is identified with a randomized number, which differs from their participant ID in order to preserve anonymity.

Table 2. Thematic Analysis of Qualitative Responses

Theme 1: Contribution to Learning

Quote #1: "Enlightening" (Participant #42).

Quote #2: "It didn't really contribute to my general understanding of brain disorders because I feel like I may have more knowledge about brain disorders from previous courses taken" (Participant #36).

Quote #3: "Undergrad in psychology, neuroscience and behaviour, with multiple classes around mental health & brain disorders" (Participant #22).

Theme 2: Person-Centered Perspective

Quote #1: "I enjoyed most the way the characters made it personal. Having the characters explaining each brain disorder made the experience more significant for me" (Participant #21).

Quote #2: "The tool contributed to my understanding by making a connection between my emotions & the content. Instead of simply listing symptoms and signs, I

will have the mental image and memory of learning what life was like from that person's perspectives" (Participant #40).

Theme 3: Immersive Experience

Quote #1: "...experiencing images and sounds right in front of me where it almost feels like my body is physically placed in that setting" (Participant #29).

Quote #2: "I enjoyed how immersive it was and being able to see parts of the brain in a 360-degree view. It was an enjoyable and fun way to learn about the various disorders" (Participant #7).

Theme 4: Suggestions for Improvement

Quote #1: "Putting a strap on the back so you don't have to hold it. Holding it makes it shaky, which takes away from the experience" (Participant #22).

Quote #2: "Make them a little more interactive" (Participant #1).

Quote #3: "Very confusing and busy. Co-ordination between reading the text and watching the visuals together was distracting. I had difficulty to concentrate" (Participant #19).

Quote #4: "...adding a way for students to check their understanding as they go in order to better synthesize learning" (Participant #7).

1) Contribution to Learning. One of our main goals was to develop an understanding of which students are most likely to benefit from the VR tool. We captured this goal in responses indicating subjectively how students felt the VR tool contributed to their learning. When asked what three words students would use to describe their experience with the VR tool, two words in particular provided strong evidence for student learning: "informative" and "educational." Over two-thirds of the students wrote one of the listed terms, suggesting that the tool was able to successfully translate knowledge.

On the other hand, there were students who did not find the tool contributed to their learning as described by the following: "I found that I did not learn anything new that I hadn't already seen in my psychology courses" (Participant #14). A major influencing factor for this was previous experience and/or knowledge relating to brain disorders. Previous knowledge came from a variety of sources including post-secondary classes, undergraduate degrees, and

employment in health care. This experience is described by one student: "I have taken a number of brain related courses through my undergrad such as drugs and behaviour, biopsychology and cognitive psychology" (Participant #33).

2) Person-Centered Perspective. One of the ways knowledge was translated was through the use of a person-centered perspective. Specifically, information about the disorders was shared through the perspective of someone living with that disorder. In doing so, the symptoms and affected brain regions became more than just facts and instead told a story. This is shown in the following: "I enjoyed that each person in the video described their own symptoms, it wasn't just a case study where someone else talks about their facts. It gave a personal touch and the emotion evoked from it made me remember more information about each person" (Participant #28).

Students felt an emotional connection with the material when it was presented using a person-centered perspective. The stories shared were perceived to be real for students and made the experience more memorable. This suggests that by adding a personal element to learning, students are able to better engage with the material, aiding in retention and understanding of content. This is described by one student: "Not only did this tool provide me with fact-based information about these disorders, but it followed up with real, applicable examples that brought the disorder to life and put it into perspective" (Participant #27).

3) Immersive Experience. The evidence suggests that students found the VR experience to be immersive and unique from traditional teaching methods. This experience is created by surrounding users in a three-dimensional environment using images and sounds. This finding is not surprising since a core component of VR is placing users into a simulated world. This is described in the following:

"Being completely immersed in a fake reality" (Participant #36). Moreover, students not only felt the experience was immersive, but they felt that this made the overall experience better. This is described in the following: "I enjoyed that we were placed into the steps of the individual with the brain disorder. I liked that there was a 360-degree view of the room as it made it more realistic and interesting" (Participant #35).

When asked what comes to mind when thinking about VR, student responses highlighted components that match closely with those found in formal definitions: 3D, technology, simulation and immersive (Madathil, 2017). This is illustrated in the following: "Advanced technology that allows the user to simulate any given, real-life situation" (Participant #12). Student responses also matched closely to how they perceived the VR tool. The same student reported: "By seeing/hearing the individuals it made it easier to connect/sympathize with the characters and those who suffer from these brain disorders" (Participant #12). Comparing student responses across questions suggests they had an adequate understanding of VR, and this experience matched their expectations.

4) Suggestions for Improvement. Students made a number of suggestions for ways the tool could be improved. This theme encompasses these suggestions and highlights some important limitations they bring to light. Students found there were aspects of the device that could be modified for convenience and quality. It is evident in responses that having to hold the device throughout the experience was uncomfortable, inconvenient and led to shakiness. A number of students indicated that a head strap was needed. This is described in the following: "Have a head strap so you don't have to hold it on your face" (Participant #36).

Additional suggestions came from an aspect of the device that was met with mixed reviews. Students appeared to be divided on the ideal amount of stimulation, with some recommending the experience be more interactive and others suggesting to limit how much is going on in each scene. These differences could be explained by personal preferences or may reflect additional unknown factors. This is shown in the following: "I wish that the environment was more interactive and live. For example, I wish I could have seen ... Linda's daughter's emotions and reactions to her mother's confusion" (Participant #27). Another student added: "The video was quite blurry for me and a bit disorienting. It was sometimes difficult to pay attention to what was being said with such vivid visuals and being able to explore the environment" (Participant #7).

A number of other recommendations varied while highlighting the same overall issue. Students felt that the tool needed to be made more accessible, so that everyone could benefit. Students had multiple suggestions for features that could be added to improve how the tool is incorporated into the classroom and maximize the number of students who are able to learn from the tool. For those with hearing or vision impairments the current device was problematic, but the addition of closed captions or customized headsets with room for glasses could be the solution. A student added: "I would have the virtual reality tool be more user friendly with closed captions. Also I would have it where you can sit and not move around. These two recommendations are because if someone is hearing impaired or has certain injuries, they might not be able to participate in the learning activity" (Participant #30).

Discussion

This paper documents the experiences of higher education students with a VR tool, Brain Stories, as part of quality improvement supported by an IDEAWORKS Catalyst Fund grant. Instead of simply telling students what they will learn in the

Brain Disorders Management program, it was believed that VR could provide a high-level overview of topics before delving into more detail in the semester. We therefore used VR as a learning hook by building interest among students and thereby providing an opportunity for quality improvement.

Our primary objective was to introduce students to three fictional characters diagnosed with brain disorders: autism, schizophrenia and Alzheimer's disease. To this end, we accomplished this goal by developing a script that provided a high-level overview of autism, schizophrenia and Alzheimer's disease. Specifically, it reviewed the prevalence of each brain disorder as well as key brain areas involved and implications for daily functioning. By using VR, this content was delivered in such a way that it piqued the interest of students and presumably acted as a foundation for future learning. The fact that the majority of students (84%) recommended Brain Stories attests to the potential educational value of this tool. However, research, using a pretest posttest design or comparison with a control group, is needed to measure whether learning was impacted in a meaningful way. This research would build on previous results obtained by Madden et al. (2018) that VR might pique the interest of students, but not always impact learning outcomes.

Upon closer examination of the students who did not recommend Brain Stories, it was identified that prior knowledge acted as a barrier. That is, if students already believed they had knowledge about autism, schizophrenia or Alzheimer's disease then it was likely that the VR experience was less enjoyable and, in turn, these students were less likely to recommend this tool to other students. This is an important consideration for Brain Disorders Management and other programs that serve as an educational pathway, and particularly in relation to mature students who have already completed some higher education training. In fact, approximately 41% of women and 29% of men aged 25 to 34 in Canada had a

bachelor's degree or higher in 2016 (Statistics Canada, 2017). One way to potentially mediate the effect of prior knowledge is to provide students with clear learning objectives for how VR is to be used in the classroom. Research shows that these objectives can provide context for learning and reduce the likelihood of VR being perceived as 'edutainment'. This point about providing a context reinforces the need to scaffold learning by ensuring that student-based factors, such as their comfort level with this technology and their academic background, are considered before incorporating VR into the classroom (DePape et al., 2019). In our case, we explained to students that VR was being used as a learning hook, which is consistent with the BOPPPS Model educational framework (University of British Columbia, 2017). As such the learning objective was not to increase knowledge per se, but to instead increase the interest to learn about brain disorders.

The second objective was to evaluate whether using a first-person perspective in the virtual reality tool was able to cultivate students' prosocial emotions such as empathy. To this end, we achieved this objective as the case study approach allowed students to relate to the fictional characters, Aaron, Henry and Linda, and to understand their conditions through their lived experiences. This human element was emphasized in the script by showing how each brain disorder impacted daily functioning, such as Aaron being perceived by his teacher as misbehaving when in fact he had difficulty understanding speech. It was captured in the qualitative responses with students reporting that they simply were not exposed to facts about each case study; there was a person at the heart of each disorder. Furthermore, when asked to rate the ability of the case studies to invoke emotions, the majority of students indicated that it was either "very good" or "extremely good".

Some students reported that the emotion they experienced made the case

studies memorable, presumably given the story-telling quality of the script. The role of empathy in knowledge retention and understanding is inconsistent across the literature, and has been studied mainly in the role of health care workers (Williams & Stickley, 2010). Further research is needed to determine whether the empathy reported by students extends beyond the classroom, such that it positively impacts how they interact with clients in their future careers. After all, empathy can take several forms (Zaki, 2019) including thinking about the mental state of others (cognitive empathy), sharing emotional experiences (affective empathy), and caring about others (empathic concern).

The use of virtual reality as a medium for the case study approach brought the person-centered perspective to life and created the feeling of students being part of each individual's world. However, some differences were noted with respect to the immersive element of Brain Stories. That is, some students wanted more immersion (e.g., interacting with characters) while other students preferred the level of immersion provided or wanted less. This tolerance for immersive environments is likely impacted by physiological factors such as susceptibility to motion sickness. This is of particular concern for our sample because research shows females are more likely to experience motion sickness in VR (cyber sickness) than males (Shafer, Carbonara, & Korpi, 2017). Since the majority of the students in our sample were women, motion sickness could have accounted for some of the individual differences found in user experience.

Interestingly, students shared some valuable recommendations about how VR could be incorporated into the classroom; many of which were related to concerns over accessibility. Specifically, the VR headset provided a barrier to users who reported physical discomfort and shakiness from having to hold the headset throughout the VR experience. Another issue involved blurred vision among students who wore glasses as they reported there was not enough space

for their glasses in the headset. The headset used in our project, Google Cardboard (<https://vr.google.com/cardboard/>), is valued for its affordability (\$20 CDN per headset). It is therefore seen as a good entry point for educators wanting to incorporate VR into their classrooms. However, other headsets such as Oculus Go and HTC Vive are available that would address some of the barriers experienced, but at a higher price point. These recommendations are in line with Universal Design for Learning (UDL) principles, which aim to remove barriers for learning, regardless if the student identifies as having a disability or not (Meyer, Rose, & Gordon, 2014). We believe these recommendations related to accessibility represent key issues that should be explored further as part of a CoP about how VR is incorporated at the higher education level. We also believe that given the newness of this technology, this CoP should include the input of educators and students alike to establish best practices for higher education classrooms.

Although Brain Stories had its strengths, this project had a number of shortcomings that need to be identified. First, our project involved a quality improvement initiative and as such, the results may not generalize to the larger population. Our project also involved a sample of convenience by involving students in the Brain Disorders Management program. This sample was predominately female, had an average age of 26 years old, reported English as their first language and had prior training at the higher education level. It is therefore difficult to compare our sample to other samples reported from research studies. As an example, a report from the U.S. Department of Education (2018) details that in any given year, 33% of postsecondary students take some form of distance education. However, 90% of our sample had previously taken an online course. Given these limitations, our findings need to be considered in the educational context in which the data were collected, with implications for research involving VR and higher education.

Conclusion

The mixed methods approach used in our project allowed us to understand what are the student-based and technology-based factors to consider when incorporating VR at the higher education level. Research is needed on this topic to measure the learning outcomes associated with VR among higher education students. This project, together with future research, will contribute to a CoP where the effectiveness of VR at the higher education level can be explored, discussed and ameliorated for future student cohorts.

Brain Stories outlines one way to use VR in that it acts as a way to generate interest and hook students into their own learning. With proper instruction and learning objectives stated outright, this tool has the ability to showcase what material is to come in the semester. Besides contributing to quality improvement, Brain Stories also reminds us to consider student accessibility in accordance to UDL principles. These concerns over accessibility can be addressed by a CoP to ensure that the power of this technology is maximized within higher education classrooms.

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Disclosure Statement: This project was funded by Mohawk College through an IDEAWORKS Catalyst Fund grant. The VR tool, Brain Stories was developed by Shain Michael Design in accordance with the Purchasing Policy at Mohawk College. The authors declare that they have no conflicts of interest. The work in this paper is original and has not been published elsewhere.