

Immersive Learning and Participatory Engagement: Connecting in the Online Classroom Through Virtual Reality


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ABSTRACT

Guided by constructivist theory, this study examines health professions student learning and engagement in the virtual classroom (VC) setting. Students (N=52) participated in a one-week VC prior to and during the COVID-19 pandemic. After participation, students were surveyed to discern their impressions of the experience, including the administration of a presence questionnaire, a key indicator of virtual environment (VE) efficacy. High student presence scores were significantly correlated with the perception that the VC facilitated learning ($r = .573$, $p = .001$). Conversely, students who perceived the course content as challenging were less likely to recommend the VC as a viable alternative learning platform. Furthermore, in terms of presence, undergraduate and graduate students were not significantly different. In summary, health professions students view immersive technologies favorably and may benefit from using such platforms as alternative or supplemental learning tools regardless of their academic level.

KEYWORDS

Health Professions Student Learning and Engagement, Immersive Learning, Virtual Classroom

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INTRODUCTION

In the pursuit of meaningful and effective training methods, the field of medical education has evolved over time. Medical simulation as a means for training health professions students gradually gained momentum in the 1960s with its introduction for the purpose of teaching cardiopulmonary resuscitation (Jones et al., 2015). Since then, advancements in technology have led to more widespread use of simulation in medical training (Jones et al., 2015). Traditional simulation usually occurs face-to-face in a laboratory with manikins or trained individuals serving as standardized patients (Rourke, 2020). This type of simulation allows students to practice clinical skills in a controlled environment but there are limitations including personnel and equipment availability as well as prohibitive costs (Bogossian et al., 2018).

As technological advances continued to grow, less resource-intensive virtual simulations were developed to interface with users at varying degrees of immersion (Cant et al., 2019). With the ability to manipulate the level of immersion came the ability to create interactions within a 3D environment that could provide experiences that more closely mimicked realistic scenarios (Repetto, 2016; Slater & Wilbur, 1997). An even deeper level of realism is achieved with augmented reality, a variation of virtual reality (VR) that draws on key environmental details to enhance the immersive environment by superimposing digital information on actual people or objects (Agency for Healthcare Research and Quality, 2020).

Online education allows students to satisfy degree requirements while learning at their own pace, on their own schedules and from any location (Martin, 2019). On the other hand, the online classroom, which often uses a discussion forum to engage students and faculty is usually considered less personal because many of the interactions found in the face-to-face classroom are lost (Andrew et al., 2021; Berry, 2017; Martin, 2019). Synchronous online instruction can provide an answer to this criticism of the typical online course by helping to increase engagement between peers and the instructor and in the process, support learning (Andrew et al., 2021; Giddens et al., 2021; Joksimović et al., 2015). In the face-to-face classroom, students are bound by time and location, in which their presence is required. If absent, students may miss valuable classroom interactions. The virtual classroom (VC) has the advantage of allowing either synchronous or asynchronous interaction with peers and instructor thereby having the potential to bring the best of both worlds to the learning experience.

The current evidence surrounding the utility of VR in medical education is inadequate as it paints an incomplete picture. Therefore, the objectives of this article are two-fold: (1) further explore the effectiveness of the Virtual Classroom and its effects on student learning and engagement; (2) evaluate differences in presence scores between graduate and undergraduate students. By addressing these two key research questions, the goal is to add to the body of knowledge surrounding the effectiveness of VR and bring the field closer to a consensus on whether its implementation produces a net benefit to health professions training programs.

BACKGROUND

As acknowledged by Pottle (2019), VR implementation in medical and nursing education has gained traction in recent years. Goldstein Market Intelligence (2020) experts forecasted the VR market for healthcare education and training would grow at a compound annual growth rate of 28% from 2019–2026, with the COVID-19 pandemic as a driving force behind this accelerated growth. In addition, a Canadian national survey of nurse educators from the Canadian Association of Schools of Nursing (CASN, 2021) reported that 31% of respondents utilized virtual simulation for the first time due to Coronavirus Disease 2019 (COVID-19) while 74% of educators had launched its use to replace clinical practice, in-person simulation, laboratory, and classroom time (CASN, 2021).

With the expansion of VR use in health care and health education research, the need for a common language in the literature became apparent. Cant et al. (2019) recommended a standardized

vocabulary stratified according to fidelity, level of immersion, and patient type. Kardong-Edgren et al. (2019) concurred and further proposed the three-tier immersion scale from Miller and Bugnariu (2016) as the standard for descriptions of virtual simulation in the literature. In this classification, low immersion delivers content via desktop and mouse interaction, moderate immersion involves one or two senses, while high immersion often involves head-mounted devices or surround projection to block external stimuli (Kardong-Edgren et al., 2019; Miller & Bugnariu, 2016).

Implementation of Virtual Reality Platforms in the Classroom: Pros and Cons

Reports on the outcomes of VR in medical and nursing education are mixed. Among the more favorable accounts, Rourke (2020) assessed the educational outcomes in most studies as being at least comparable, sometimes better than traditional simulation with the added benefit of less labor-intensive faculty and environmental support. Shorey and Ng (2021)'s systematic review results indicate that six of eleven studies comparing experimental studies using various levels of immersive VR to teach nursing students produced significantly higher results for cognitive skills than with traditional simulation. Furthermore, in four of thirteen studies, psychomotor skills were determined to be more developed in the VR group than in the control providing additional evidence of the utility of this approach (Shorey & Ng, 2021).

Numerous benefits of implementing VR in the training of medical professionals have been noted. The literature points to high-immersive technology being equally successful at teaching anatomy to medical students as cadaver and atlas groups (Chen et al., 2020) with the additional effect of increased empathy in medical and other health professions students (Dyer et al., 2018). Evidence also suggests that high-immersive VR is effective in practical applications: Butt et al. (2018) used high-immersive VR to teach urinary catheterization to undergraduate students and reported that the VR group produced equal pass rates similar to those who practiced with a task trainer.

Low-immersive VR has also proven beneficial, helping health care professions students achieve competency with various skills. Of note, nursing students who learned newborn assessments in VR had better knowledge retention than those trained in a face-to-face environment although the latter group displayed higher self-confidence (Hudder et al., 2021). As another line of evidence in support of VR utilization, a small study in which low-immersion VR was used to teach medical students and residents resource management in rheumatology investigations resulted in a high rate of accurate diagnoses at the end of training, training that was relatively inexpensive to provide (Zhou et al., 2019). Furthermore, interprofessional low-immersion VR successfully improved positive interprofessional attitudes of graduate health professions students towards palliative care (Lee et al., 2020).

Although there is a case to be made for its utility in the educational setting, VR is not without limitations. While it has been employed successfully in the educational setting as outlined in the aforementioned studies, it is important to acknowledge the challenges this technology presents. One such complication is technological uncertainty, including limited connectivity, the need for higher internet bandwidth, and often unpredictable system malfunction (Crane et al., 2021). In addition, equipment requires maintenance and regular updates to facilitate optimal performance (Shorey & Ng, 2021). Another major drawback is the need for delivery of an environment that is so engaging that the participant is immersed and attentive rather than being distracted by external factors. The level of immersion may determine one's sense of presence (Dang et al., 2021). A strong sense of presence is necessary for increased engagement and learning. Therefore, the more realistic the virtual environment (VE), the more effective it is as a learning platform (Crane et al., 2021; Shorey & Ng, 2021). However, some users report out-of-context headaches, dizziness, and motion sickness from more immersive environments (Birbara et al., 2019). Peterson et al. (2018) found that deeply immersive VR environments can deliver realistic experiences strong enough to induce physiological stress if the embedded task is one that produces the same effects in real life. An example is the case of users' VR experience with dynamic balance tasks in which virtual heights were projected for beam-walking (Peterson et al., 2018). In such a case, the physiological stress the user may experience

is in direct alignment with the task at hand and provides a true-to-life response providing realistic training conditions that mirror the conditions under which the user may need to operate in the future.

Designers of content for immersive technology environments should be mindful of the audience for whom they are designing these platforms. Although virtual classrooms accessed through a desktop without the use of a headset do not provide in-depth user immersion, designers are still reminded to be careful to include only content that is specific to course objectives and that minimize distractors. More importantly, individuals with low technology affinity, regardless of age, are more focused on technical issues during learning. Studies suggest that there is a negative association between users' age and their desire to use or interact with a VR component. This is expected, as the younger generations are more accustomed to using multiple technologies to function daily. Additionally, female students and individuals with low technology affinity were found to be more concerned with technical issues associated with the VR (Willicks et al., 2018). These individuals are more likely to interpret the use of VR in education as not advantageous (Martin, 2017; Miller, 2014). On the same line, McKeown and Anderson (2016) convey that graduate and undergraduate students differ in their intent and use of technology for learning; whereas graduate students often have the choice to complete their education online and may have a more structured and self-regulated approach toward learning, undergraduate students may also want an online option with the same quality and similar experience as face to face learning. In combination with appropriate design elements, continued advancements in virtual learning technology may help to strike the proper balance between presence and optimal learning outcomes while reducing out-of-context negative emotions toward virtual learning.

Cost-Benefit Analysis: Virtual Reality vs. Traditional Simulations

By and large, health professions students exposed to training using VR strategies recommend this educational experience (Birbara et al., 2019; Crane et al., 2021). Students trained using VR consistently rate it as highly engaging, entertaining, and beneficial (Butt et al., 2018; Chen et al., 2020; Lee et al., 2020). In addition, the overall financial investment in VR is typically lower than that of a traditional simulation laboratory and therefore has the potential for significant return on investment (Shorey & Ng, 2021; Yu & Mann, 2021). For example, a neonatal intensive care unit in Ohio that compared the cost of VR training for disaster evacuation to live training with manikins found that the initial investment for VR was substantially higher than the projected cost for traditional simulations but generated a long-term cost-savings because the costs associated with subsequent VR training is minimal, while live training requires substantial sustained investment (Farra et al., 2019). Additional identified benefits to including VR are as follows: Faculty and students may need minimal training in equipment usage; depending on the immersion level, VR may require very little space or faculty supervision, allowing educators to focus on other skills that may not be as well suited for virtual simulation (Cant et al., 2019); unlike face-to-face simulation which has more restricted availability, accessibility is enhanced therefore students have the option of continuing to practice skills at their convenience (Cant et al., 2019; Shorey & Ng, 2021).

THEORETICAL FRAMEWORK

This study was guided by constructivist theory (Chen, 2009) which posits that individuals bring their life experiences into the learning environment and these experiences influence how they approach problem-solving and learning as they process new information. Depending on the environment and the teaching method used by the instructor, students can combine the information they are currently receiving with their prior knowledge and experiences as a point of reference to help them develop understanding. According to Chen (2009), VR can be viewed as a deeply structured environment for learners to engage and construct new meanings that aid the learning process. Proponents of constructivist theory suggest that student learning can be enhanced by their active involvement in constructing their own knowledge as they engage with the environment that delivers the information.

METHODOLOGY

Research Questions

RQ1: Does a customized virtual classroom setting support student learning and student engagement as observed via quiz score and student interactive engagement in the course?

RQ2: Are there any significant differences in presence between graduate and undergraduate students?

RQ3: Do the variables of interest, uniquely or collectively contribute significantly to student reported presence in the VC?

Virtual Classroom Design and Deployment

To address the research questions, a low-immersion VC developed by Rockcliffe University Consortium was used to deliver health promotion and disease prevention course content to health professions students. For the VC, participants of this study chose an avatar, downloaded the VE, and accessed Rockcliffe University Consortium virtual classroom housed in Linden Lab's Second Life Virtual World. A wide array of universities utilize the classroom spaces in Second Life to teach and engage students. Second Life is a 3-D virtual world and is described in more detail by Rudolph-Solero et al. (2021). Students utilized Canvas as the Learning Management System to access the course announcement, course onboarding document, the quiz, and the questionnaire. The VC was designed to be appealing for an engaging learning experience during the virtual session with the instructor. The designed floor plan for the VC accounted for the order students were expected to be exposed to each element in the classroom. The design ensured that the chairs facing the instructor's podium were the first items visible; as the students' avatars walked forward to be seated, they could see the displays, projected screens, and e-books arranged in the periphery of the room similarly to a lab classroom. The more dense and interactive models were located on the back of the class (Figure 1 illustrates the proposed design of the classroom). The chair arrangements intentionally faced the instructor's podium to indicate an existing lecture component. The instructor-student and peer-to-peer interactions immediately followed the brief lecture with the instructor leading the students to each classroom element. The classroom was situated on top of a mountain and to visit the library, the students were encouraged to fly there from the classroom. The students' avatars could fly to the front of the library and walk in to the medical and nursing section to access other recommended e-books. The learning outcomes guiding the content, discussion questions, and quiz associated with the course were for the participants to describe the social, environmental, and genetic risk factors for chronic disease and to understand the role of health care professionals in health promotion.

Figure 1. Floor plan of proposed structure and room arrangement of VC



Participants

Upon receiving Institutional Review Board approval, undergraduate biology pre-med, pre-nursing, and graduate health profession students were recruited and invited to participate in a one-week, researcher-developed, non-credit VC. The course was an abbreviated version of an existing Health Promotion and Disease Prevention course, created for the study. The study sample was composed of 52 undergraduate and graduate health professions students. The student participants were recruited before and during the COVID-19 pandemic from a large private southeastern university in the United States. Of the 52 participants, nine (17.3%) were male and 43 (82.7%) were female. With respect to academic level, 25 (48%) were graduate health professions students, and 27 (52%) were undergraduate students enrolled in their junior or senior year. Prior to the COVID-19 pandemic, most of the recruits were undergraduate students (n = 21), while there were only six undergraduate students included in the study during the COVID-19 pandemic. Eleven graduate health professions students were recruited before the pandemic, and fourteen were recruited during the pandemic.

Student participants were registered into the course and logged in to the Canvas instructional platform to access course guides, quiz and presence questionnaire. The participants received onboarding instructions in the course announcement because of student familiarity with this type of communication from online, hybrid, and face to face courses. The goal was to ensure that onboarding instructions were simple, short, and minimal; as such only one announcement was utilized, which contained course expectations, documents, timing, and a link to create a Second Life account and choose an Avatar. The students received a document highlighting the steps along with screenshots associated with each step to create a Second Life account and familiarize themselves with the virtual classroom prior to their session with the instructor. The participants were also instructed to contact the instructor should they have any issues with the Second Life platform. On the first day of attendance, participants were scheduled to meet in groups with the instructor for a 15–20-minute VC session; the session with the instructor did not last more than 25 minutes and after dismissal, the students were free to explore the VC and its content on their own. During the virtual session, the students listened to a brief lecture delivered by the instructor and completed an in-class activity. They accessed the VC course content which focused on health promotion and disease prevention, chapter notes on genetics and environmental factors as contributors to health and diseases, a YouTube video on health management, and a TEDMED talk case-study on patient disease management using technology. Following the virtual session, participants were given access to the PowerPoint slides used for the lecture and book chapters to study via the VC. The student participants completed the presence questionnaire and a five-question quiz on the overall content learned by the end of day seven of enrollment in the course (Figure 2). Figure 3 illustrates the VC platform layout given to students as a quick instruction guide.

Figure 2. Schema of student participant progression through the course

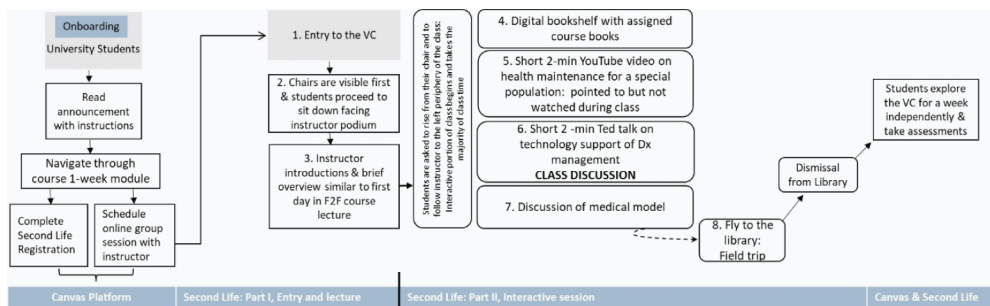


Figure 3. Virtual classroom with quick instruction guide for students



Instruments and Measures

Presence

Presence is conceptualized as the degree of immersion that a participant feels in a VE such that they are not aware of outside influences. Perceptions of presence were assessed through administration of the Presence Questionnaire (PQ) which was first introduced in 1998 by Witmer and Singer of the Army Research Institute (Witmer & Singer, 1998a). The Questionnaire has been updated, adapted, implemented and validated widely in diverse settings and languages; the current study used the original version of the PQ which contains 29 items for self-reporting one's experience of presence in a VE, assessing one's immersion in the VE as well as level of involvement in a specific activity. Reliability of the PQ was based on measures of internal consistency, Cronbach's alpha, which yielded a reliability score of .88 for the 19-item version (Witmer & Singer, 1998b). The PQ attained content and construct validity based on item reduction from cluster analysis, indicating that presence as measured by the Presence Questionnaire is a valid construct (Witmer & Singer, 1998b).

The PQ subscales included sensory fidelity, involvement, adaptation/immersion, and interface quality. Sensory fidelity refers to the extent of engagement to the VE of the participant; involvement refers to how absorbed the participant is during the experience; adaptation/immersion is the speed with which the participant can adapt and feel a part of the environment, while interface quality is the measure of the degree to which audio and visual components impede on the participant's concentration (Dang et al., 2018).

Student Engagement

For the purposes of this study, student engagement was conceptually defined as student live interaction in the VC and student-content engagement on Canvas. Operationally, student live engagement was measured using four observed events during the 15–20-minute live session in the VC. Students were

given a VC engagement score based on the following criteria: their verbal or written responses via chat to the instructor's discussion questions, the ability to recall pertinent course information, and the degree to which they actively followed the instructor to different sites within the VC. Student-content engagement was measured by the number of times students viewed the course guide and pre-course instructions on Canvas. It is important to note that the instructor observed and rated the student participants on three actions displayed by their avatar, including following the instructor to the simulated medical model and to the virtual library, clicking on contents when prompted, answering questions verbally and by chat when prompted. The participants were asked discussion questions such as 'how might a health monitoring technology device assist an individual with a chronic illness, how do genes and the environment interact in disease causation, what is the health provider's role in patient health promotion, and what health promotion considerations should be given to special populations (i.e. homeless, displaced, disadvantaged individuals)?'

Student Learning

Student learning was conceptualized as the ability to recall information from the assigned chapters. To operationalize student learning, students completed a knowledge quiz based on the reading content in the learning module. The quiz was composed of five multiple-choice questions, testing student knowledge only on the content of the assigned chapters in the books utilized for the course. Though some of the content was highlighted during the virtual lecture, the students were required to read and interact with the book further on their own time. Excluded from the quiz items were the discussion questions, dialogue on the TEDMED talk, and content on case scenarios discussed during the live VC session. These interactions were reserved for participation score and were excluded from the student learning measure. The quiz was created by identifying and focusing on three of the key learning outcomes, which included the understanding that multiple factors interact in disease causation, the evaluation of mechanistic claims in disease causation, and the consideration for evidence in disease causation claims. As such, quiz items were generated from the course objectives and focused on the mechanisms in medicine topic addressed in the course. The intent was for the respondents to recall information about intersecting and contrasting disease causation concepts that were briefly lectured and were found in their reading. Respondents were asked five higher order questions to ensure content validity of the quiz and to test knowledge application. Two examples of these questions are as follow:

1. Disease mechanisms are well developed and understood. They demonstrate that health is not simply a metabolic response to toxins, but includes__
 - a. Complex interactions involving maternal and paternal genotypes.
 - b. Relational process involving social and biological interactions.
 - c. Higher dependence on mostly environmental factors.
2. According to the biological level of mechanisms, DNA_
 - a. Can change based on environmental factors.
 - b. Cannot change and neither does its expression.
 - c. Cannot change, but gene expression can change.
 - d. Can change as a response to gene expression.

Student Satisfaction

Student satisfaction was conceptually defined as students' perception and recommendation of the VC. Operationally, student satisfaction was calculated by the sum of two questions: student recommendation of the VC platform for learning and engagement, and enjoyment of the VC. The questions included in the calculation of student satisfaction were dichotomous (yes, no).

RESULTS

To address the first research question which aimed to assess whether a virtual classroom could adequately support student learning and engagement, a series of observations and questions were utilized to perform the assessment. The same participant pool was studied to address the second research question which was focused on determining whether a significant difference exists between graduate and undergraduate student presence and overall learning satisfaction in the VC. Furthermore, because the COVID-19 pandemic heavily impacted the study results, and some of the participants were recruited prior to the COVID-19 lockdowns, the study also aimed to determine if there were differences in students' perception of the VC before and during the COVID-19 pandemic, and whether these factors along with technology affinity affected the students' PQ score.

Statistical analysis was performed using Statistical Package for the Social Sciences IBM SPSS version 27.0. Descriptive statistics, correlation and group comparison analyses were conducted to answer the research questions. The variables of interest for this study were student learning, student engagement, student satisfaction, and presence. The study did not assess if the VC enhanced or improved student learning and engagement, but rather, if the VC supported student learning and engagement. As such, this study did not use a control group design.

To address whether the study VC supported student learning and engagement, correlation analyses were used to assess the relationships among these variables: PQ score, quiz score, student satisfaction, and student engagement. Based on the instructor's observations of the participants' involvement in the VC (Figure 4), many of the students demonstrated high engagement during the live sessions and on the Canvas platform ($n = 42$). This was consistent with their estimated engagement on Canvas by the following: number of times students viewed course information pages on the first day (announcement, VC guides, assignment pages) ($M = 23.10$, $SD = 12.62$), and average times they viewed course information on the day they attended the live VC session ($M = 48.96$, $SD = 25.41$). The students viewed the guide an average of four times ($M = 4.24$, $SD = 2.77$) and accessed the JPEG image (Figure 1) with instructions for the VC prior to logging into the VC at least six times ($M = 9.91$, $SD = 3.19$). The overall mean PQ score for graduate health professions students ($M = 101.28$, $SD = 23.74$) was higher than the overall mean undergraduate PQ score ($M = 97.58$, $SD = 17.19$) however, the trends were consistent (table 1). All students' mean PQ score before the COVID-19 pandemic was higher than the PQ score during the COVID-19 pandemic ($M = 103.17$, $SD = 14.10$) vs. ($M = 93.63$, $SD = 27.55$) but there was no statistical significance.

(Figure 4. Top left: instructor introductory lecture with students sitting down, facing the podium, the instructor will walk to the podium. Top right: students in front of heart model; students will turn to interact with the model. Middle left and right: instructor leading the first interactive segment of the class, pointing the students to the required books and YouTube video, followed by the TEDMED video with a collaborative discussion among the students. Bottom left and right: the instructor leading the students to fly to the library to retrieve other recommended books.)

Spearman correlations, two-tailed, with significance at $\alpha < 0.05$ at 95% CI were conducted on the variables of interest. See table 2 for correlation analysis results. Overall participants' PQ scores are significantly correlated with satisfaction with the VC ($r = .580$, $p = .001$), and their belief that the VC platform facilitated content learning (CL) ($r = .573$, $p < .001$). Students who perceived that the VC platform facilitated content learning were more likely to recommend it as an alternative learning platform compared to face-to-face formats ($r = .555$, $p = .001$), and were more likely to view the image with the instructions about the VC prior to the live class session ($r = .527$, $p = .017$). However, students who perceived the course content as challenging were less likely to recommend the VC platform as an alternative learning environment. Surprisingly, the view that course content was challenging did not significantly correlate with the perception that the VC made the course content more difficult ($r = .256$, $p = .172$). Student perception of course content difficulty, time spent on Canvas, number of times students viewed the course guides, and student quiz score did not

Figure 4. Different scenes during the live VC interaction



Table 1. Descriptive statistics for four outcome measures

	Undergrads (N=27)		Grads (N=25)	
	M	SD	M	SD
PQ score	97.58	17.19	101.28	23.74
Student satisfaction	3.05	1.81	2.73	1.62
Student engagement	13.17	3.44	20.0	4.0
Quiz score	4.43	0.598	4.45	0.934

significantly correlate with PQ score ($r = .242, p = .198$; $r = .186, p = .385$; $r = .117, p = .625$; $r = .210, p = .290$), consecutively.

The estimated time spent on the Canvas platform was not significantly correlated with any of the variables of interest. Student quiz score was a low variance variable, with 96% of the participants scoring 80% or higher on the quiz, likely due to the number of questions on the quiz; quiz score

Table 2. Descriptive statistics and correlations for study variables

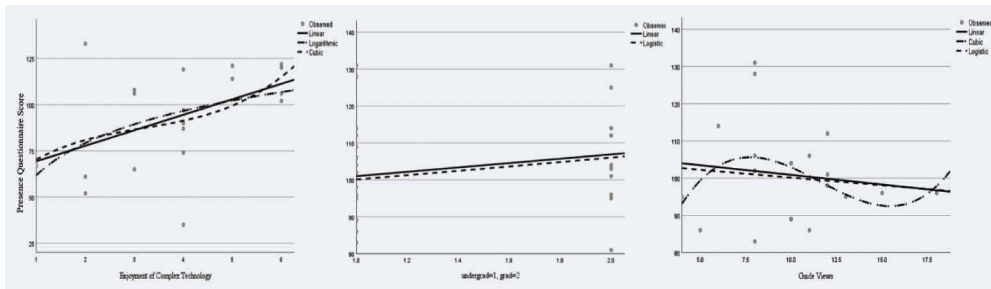
Variable	<i>N</i>	<i>M</i>	<i>SD</i>	1	2	3	4	5	6
1. PQ score	52	99.46	20.65	—					
2. Student satisfaction	52	—	—	.580**	—				
3. CL facilitator belief	52	—	—	.573**	.561**	—			
4. Guide views	49	4.24	2.77	.117	.310	.168	—		
5. Student recommendation	52	—	—	.346	.592**	.555**	.323	—	
6. Quiz score	49	4.44	.72	.216	.109	.019	.123	.026	—

Note: Correlations ** $p < .05$ (2-tailed)

was not significantly associated with any of the other variables. Because group sizes were unequal, variances were assumed to be heterogeneous. As such, independent *t* tests with bootstrapping analysis were conducted with two groups based on their enrollment status as graduates or undergraduates to address research question two. The overall undergraduate student ($n = 27$) presence score ($M = 97.58$, $SD = 17.19$) compared to graduate health professions student ($n = 25$) presence score ($M = 101.28$, $SD = 23.74$) was not statistically significant as measured by PQ score, $t = .88$, $p = .351$. Further comparison was made regarding overall student PQ score before the COVID-19 pandemic ($M = 103.17$, $SD = 14.10$) and during the COVID-19 pandemic ($M = 93.63$, $SD = 27.54$) to investigate student receptivity change due to the pandemic. It should be noted that more undergraduate students participated in the study before the COVID-19 pandemic while more graduate students participated during the pandemic. Non-parametric correlation indicates that class status (graduate vs undergraduate) was not significantly correlated with PQ score ($r = 0.188$, $p = .196$), indicating that overall, class status did not contribute significantly to PQ score. The *t* test revealed that there was a statistically significant difference between PQ score before the pandemic and during the pandemic $t = 13.467$, $p < .001$, indicating a perception of deeper presence in the VC before the pandemic. However, student satisfaction was not significantly correlated with class status or participation before or during the COVID-19 pandemic ($r = .039$, $p = .791$; $r = .098$, $p = .509$). Furthermore, there were no significant differences in satisfaction between pre-pandemic participants and participants during the pandemic $t = 3.622$, $p = .063$.

Further analyses were conducted to investigate the relationship between the targeted variables and to assess if they explain PQ score as an outcome variable. Because the curve estimation procedure provides estimates of regression statistics with the generation of plots for different models, it was used to assess if any significant linear or non-linear relationship exists between PQ score and student status, quiz score, guide views, and student belief that the VC platform facilitated content learning. The curve estimation plots for linear, cubic, and logarithmic models reveal that these variables, except for content learning facilitator belief, may not provide a good explanation for modeling PQ score (Figure 5). Affinity to technology may be an important component to explore regarding student acceptance of complex technology-based learning platforms, including VR and VC such as the one utilized in this study. For purpose of the third research question, student enjoyment of complex technology was assessed on a six-point Likert scale for any association with PQ score. Further, student belief that the VC platform facilitated CL, and student satisfaction with the VC as a learning platform were assessed within the model. As demonstrated earlier with other variables, the correlation results suggest that there is a positive and significant relationship between PQ and student belief that the VC platform facilitated CL, student enjoyment of complex technology, and student satisfaction with the VC ($r = .695$, $p = .001$; $r = .464$, $p = .046$; $r = .580$, $p = .001$). Since the student factors affecting PQ score are rather complex, the study further investigated the predictive ability of these variables within a model. A regression analysis was conducted where student belief that the VC platform facilitated

Figure 5. Curve estimates on 3 independent variables for three models

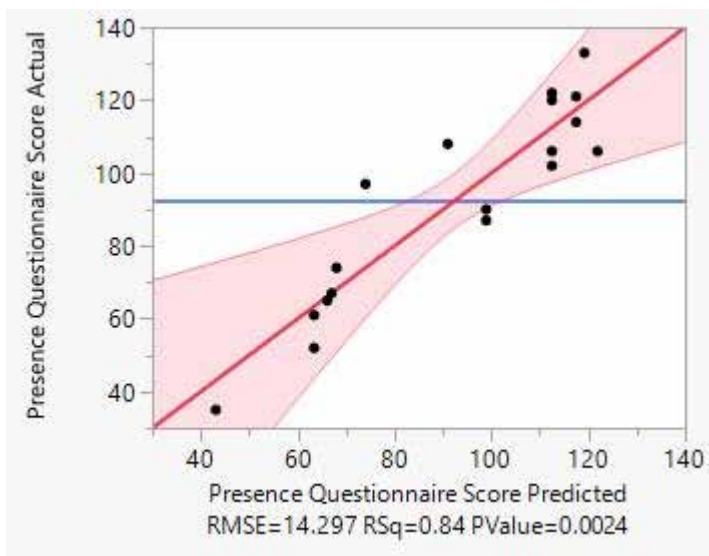


CL, student enjoyment of complex technology, and student satisfaction with the VC were considered as predictors to PQ score. The results from the regression analysis suggest that student belief that the VC platform facilitated CL, student enjoyment of complex technology, and student satisfaction with the VC predict a significant amount of criterion variance. The model was significant $F(3, 47) = 7.762, p = 0.003, R^2 = .840$ (Figure 6). Further, student enjoyment of complex technology did not contribute significantly to the model, while student belief that the VC platform facilitated CL, and student satisfaction with the VC were shown to contribute significantly to the model, ($t = 3.066, p = 0.062; t = 9.185, p = 0.013; t = 5.965, p = 0.035$) consecutively.

DISCUSSION

This study had three purposes; first, it aimed to determine if a customized virtual classroom supported student learning and engagement as observed via quiz score and student virtual interactive engagement. Second, the study aimed to examine if any significant differences existed in presence score between graduate and undergraduate students. Third, the study aimed to explore if the variables of interest, uniquely or collectively contributed significantly to student reported presence in the VC. In regard

Figure 6. Actual by predicted plot of regression model predicting PQ score



to the study's first aim, correlation analyses were conducted to examine the relationship between PQ score, student satisfaction, student belief that the VC facilitated CL, guide views, time spent on Canvas, perception of course content difficulty, student recommendation, and quiz score. The next focus was on the relationship between student class status, PQ score, satisfaction with the VC, recommendation of the VC, and student belief of the VC platform interference with learning. Student perception of course content difficulty, time spent on Canvas, the number of times students viewed the course guide, and student quiz score did not significantly correlate with PQ score. Nonetheless, student facilitator belief of CL and student satisfaction with the VC were significantly correlated with PQ score. This suggests that PQ score is associated with student satisfaction and student belief that the VC does not interfere with learning.

Grounded on *a priori* evidence concerning the incorporation of VR platforms for student learning, selected student actions and responses were examined among a group of undergraduate and graduate health professions students. Particularly, interaction with course instructional content, pre-course content, guides, announcements, and interaction during the live sessions were assessed to determine if the VC platform supported student learning and engagement. The results revealed that students engaged with the VC without sacrificing student learning. Similar results were obtained by Butt et al. (2018) and Chen et al. (2020). Studies have reported positive cognitive learning outcomes with VR (Bayram & Caliskan, 2019; Chen et al., 2020; Dyer et al., 2018; Hudder et al., 2021; Liu, 2021). A systematic review that compared three learning environments: VR, face-to-face, and traditional simulation with their associated learning outcomes in terms of cognitive, psychomotor, and affective behaviors found that VR was the most effective way to learn cognitive content (Shorey & Ng, 2021). The findings of the current study are consistent with the assertion that a virtual learning modality can support and sustain student learning if it is structured and created with appropriate content.

Online and virtual courses are designed to reconstruct real-life academic experiences without sacrificing rigor and the learning experience. The measurements of the four PQ subscales, sensory fidelity, involvement, adaptation/immersion, and interface quality help support validation of the virtual classroom as an effective approach for health profession student learning and engagement. As such, incorporating these constructs in this study provides evidence of the participants' perceived realism in the virtual classroom. The subscales were able to discriminate between participants who were highly engaged during the virtual session compared to those who were less interactive. In particular, sensory fidelity and involvement were accurately captured by the respondents' perception of immersion which was consistent with the instructor's observation of the participants' virtual behaviors. Further, though the participants accessed the VC without head-mounted VR sets, high adaptation/immersion was expressed by the respondents, in part due to the visual appeal offered by the VC along with the incorporation of enjoyable activities such as flying to the library for a fieldtrip, communicating with the robotic library attendant, interacting with the medical models, and watching video case-scenarios within the VC. Because these events were sequentially and intentionally incorporated within the whole VC experience, they allowed the interaction to be more immersive, thus strengthening student learning and participatory engagement.

In the current study, students who indicated that the course content was not challenging were more likely to propose the VC as an alternative environment for student learning and student engagement. The results suggest that a VC can be a viable solution during student illness, inability to attend class physically, or during pandemic situations when face-to-face classroom time is limited or nonexistent. The literature also suggests that VCs can be used for teaching challenging content including management of mental health and end-of-life care. Participants in Lee et al. (2020) were able to learn about schizophrenia symptom management while engaging in a virtual platform that provided an immersive experience that is nearly impossible to replicate in the traditional classroom setting. These participants also reported that VR is a safe and comfortable alternative for learning complex palliative care skills.

This study also demonstrates a statistically significant correlation between student sense of presence, satisfaction with the learning platform, and the belief that the low-immersion VC assisted with learning the content. Dang et al. (2021) stated that the level of immersion might affect a participant's sense of presence and engagement. This study has established that a low-immersion VC can be effective and is consistent with the findings of other practitioners (Hudder et al., 2021; Rudolphi-Solero et al., 2021; Zhou et al., 2019). The students involved in the study before the COVID-19 pandemic had higher engagement than those who participated during the pandemic when online learning was the primary option for most. Research shows students felt significant burden, role strain, and stress from the sudden change to exclusive online learning during the COVID-19 lockdowns (Suliman et al., 2021; Wallace et al., 2021). These feelings may have contributed to lower student engagement and presence during the pandemic in this study. Despite lower engagement, there were no significant differences in student satisfaction during the pandemic compared to pre-pandemic scores.

Another aim of this study was to evaluate the variations in presence score between undergraduate and graduate students. Most of the undergraduates recruited before the pandemic were face-to-face students who later had to attend class virtually from home. In contrast, most of the graduate students were recruited via their regularly scheduled online classes. Despite the variations in these student populations, the data collected reported no significant difference in presence when comparisons between undergraduate and graduate students in the VC environment were drawn. These results are consistent with the findings of Fogg et al. (2020) in which undergraduate and graduate student satisfaction with VR was assessed for clinical hours during the pandemic and produced mostly positive responses to the VC.

The findings from this study suggest that purposeful, timed, and relevant content and activities can be strategically integrated within a virtual classroom to facilitate health profession student learning and engagement. The results support the view that structured virtual learning platforms such as a VC can generate an efficient and rich learning space for health profession students to learn and engage with peers. The typical scene in online synchronous and asynchronous classes is that of the instructor as the center, providing lectures to students via videoconference systems or recordings where the interaction is often one-directional and group work and discussion posts seem forced and repetitive. Instead, this study demonstrates that with the course learning outcomes encapsulated within an interactive virtual platform, students were able to retain an extensive amount of information and connected with peers during a short, fixed, interactive instructor-facilitated VC session. By targeting short resourceful presentations within a virtual environment and embedding interactive resources for independent student access, the instructor will be compelled to incorporate more collaborative activities that facilitate multi-directional interactions. As such, these implementations will allow students to involve multiple sensory systems to be intentionally present, learning, and engaging during the virtual session and during their exploration of the VC on their own. Completing individual assessments outside of the learning environment enables students to recall the whole experience; consequently, a recall of pertinent information that were shared and discussed. The pedagogical approaches for this learning environment are well defined and structured, providing support for different types of health profession student learners. In such virtual environments, students can learn effectively through meaningful contexts, listen to lectures, and engage with peers through prompts without reducing the quality of learning activities.

Limitations and Recommendations

There are several limitations noted in this study. This study was a single-site study in the Southeast of the United States that included participants before and during the COVID-19 pandemic. It examined whether the VC supported learning and engagement, not whether it enhanced it. Future studies should assess and compare learning outcomes with VR against other traditional methods of classroom instruction. The use of a control group could have yielded more robust results leading to more concrete outcome measures. Additionally, part of the study took place during a global pandemic and data on

participants' work barriers or the social and academic barriers imposed by the COVID-19 pandemic were not collected from the student participants. Furthermore, because all 52 of the participants were health professions students, it is not clear how much or to what degree the pandemic affected their participation and responses. Students had to adapt to a new normal which included hybrid classes, social distancing, mask-wearing, and other restrictions that may have influenced outcomes due to the added stressors. These changes could have resulted in negative or positive impacts on student engagement and learning. Moreover, small sample sizes and lack of homogenous groups may limit the ability to apply these findings to other participant groups. Future research should include larger sample sizes, more robust designs, and multicenter involvement.

CONCLUSION

This study aimed to investigate the effectiveness of a low-immersion VC on student learning and engagement. The results suggest high learner engagement with no significant differences in outcomes between undergraduate and graduate student participants. Participants were satisfied with the VC as an alternative learning platform. The results are consistent with Butt et al. (2018) who demonstrated that high-immersive VR can yield equal pass rates among VR participants compared to face to face learners. Similar to the findings from this study on student perception of the VC's ability to facilitate learning, Zhou et al. (2019) suggest that 85.7% of participants in an online virtual case scenario felt more comfortable with working the actual cases after completing the virtual case training. These results, as a whole, suggest that a structured virtual classroom in which the design and delivery account for the learner's characteristics, may contribute significantly to student learning and engagement, especially during unprecedented situations such as the ones imposed by the COVID-19 pandemic. Evidently additional research respective to affinity to technology is needed to examine the use of immersive technologies in teaching health professions students.

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CONFLICT OF INTEREST

The authors of this publication declare there is no conflict of interest.

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