IMMERSIVE VIRTUAL REALITY AND ARTIFICIAL INTELLIGENCE FOR ENHANCING STUDENT PREPAREDNESS FOR CLINICAL EXAMS

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Abstract

Introduction: Test anxiety is a common issue among post-secondary students, leading to negative consequences such as the increased risk of dropout, lower grades, and limited employment opportunities. Students unfamiliar with the test-taking environment are more likely to have test anxiety. This study aimed to explore virtual reality (VR) and artificial intelligence (AI) as potential solutions to reduce test anxiety in health science students preparing for clinical exams. By utilizing an AI-powered virtual testing environment with interactive virtual patients, students acted as medical professionals in a simulated clinical setting, allowing them to familiarize themselves with the environment and potentially reduce their anxiety levels. The study utilized AI in the form of a generative pre-trained transformer (GPT) to generate responses from virtual patients. System was evaluated on its ability to reduce test anxiety.
Objective: To assess the efficacy of a VR simulation of a clinical setting in reducing student anxiety for a clinical exam and gather student perspectives on their VR simulation and coursework experiences to better understand their learning environment.
Methods: First-year health science students were invited to participate in a VR session that took place three-days before their clinical exam. Students exposed to VR (YesVR) and those who opted out (NoVR) had their anxiety levels compared to one another using the State Trait Anxiety Inventory (STAI) and Test Anxiety Inventory (TAI). Immersive VR simulation included history-taking and cognitive assessment modules, allowing students to communicate with virtual patients in natural language in a virtual clinic. Virtual patient responses were generated by GPT, fine-tuned with transfer learning techniques based on real-world student and standardized patient video recordings. After completing their clinical exams, students were invited to participate in semi-structured interviews and focus groups.
Results: A total of 108 students participated in the quantitative aspects of the study (mean aged 24.53 years, *SD* 2.64): 61 for the NoVR group (mean aged 24.52 years, *SD* 2.42) and 47 for the YesVR group (mean aged 24.54 years, *SD* 2.93). There was a significant difference in state anxiety scores between groups, with NoVR showing greater anxiety scores (mean 51.69, *SD* 11.87) than YesVR (mean 39.79, *SD* 12.21) (t_{106}=5.10, P=<.001, Cohen d = 0.99). The mean difference was 11.90 units (95% CI 7.28-16.53). A total of 25 students participated in the interviews and focus groups – 16 from interviews and 9 from focus groups. The major themes emerging from focus groups and interviews were overall student background, exam feedback, fear of the unknown, self-consciousness, and the exam environment.
Conclusion: This study highlights the potential of AI-enhanced VR as an effective tool for reducing test anxiety and increasing student familiarity with clinical exam environments. The results suggest that VR may reduce ambiguity and uncertainty, which are key contributors to test anxiety. The findings provide valuable insights into the potential of VR and AI in addressing test anxiety.

Keywords: *Virtual reality, artificial intelligence, student anxiety, examination preparation, learning tools.*

1. Introduction

1.1. Campus anxiety

Anxiety is a natural and innate reaction, readying the body for upcoming situations that are perceived to be risky or harmful (Perrotta, 2019). This implies a theoretical concept that has the potential to occur in either general or specific contexts, with *predisposition* (ie, trait anxiety) representing how often or strongly the response generally occurs and *transitory* (ie, state anxiety) representing a reactionary response, prompted by a present circumstance (Spielberger et al., 2015). Anxiety experienced in post-secondary education may cause numerous long-term implications, including higher risk of student drop out, decreased academic performance, reduced employment opportunities, and financial losses in billions of government dollars per year (Pascoe et al., 2020). The Intolerance of Uncertainty model (IUM) theorizes that people may inherently have an intolerance of the unknown, resulting in ambiguous situations being perceived as threatening, resulting in increased worry and anxiety (Dugas et al., 1998). It is common for students to feel symptoms of test anxiety, when preparing for practical exams with uncertain elements.

1.2. Reducing anxiety

One method of conditioning individuals to cope with anxiety-inducing scenarios is through *in vivo* exposure, where individuals are gradually exposed to real-world situations until their stress levels are reduced (Freitas et al., 2021). Virtual Reality (VR) can also be used to create computer-generated environments that replicate real-world situations to help alleviate anxiety, which is known as VR exposure therapy (VRET). VRET is also referred to as *in virtuo* exposure. For more details about the immersive and interactive aspects of VR, refer to the studies conducted by Concannon and colleagues in 2019 and 2020. For cognitive adaptation (e.g., improvement of memory, information processing, problem solving and logical sequencing), VR training of procedural tasks has shown improvements in the brain's frontal lobe, which is responsible for cognitive functions such as the ability to recall prospective memory tasks and achieve precise objectives based on time and events (Yip & Man, 2013). VR may improve procedural memory by altering neural plasticity to improve working memory (Grealy et al., 1999). VR training of daily living activities may improve attention and cognitive function (De Luca et al., 2019). When researching how students respond to VR simulation, a mixed-method approach recommends combining quantitative evaluations with student feedback to better understand their motivations (Bennett et al., 2017).

1.3. Aim of this investigation

To assess the efficacy of a VR simulation of a clinical setting in reducing student anxiety for a clinical exam and gather student perspectives on the VR simulation and coursework to better understand their learning environment.

2. Methods

2.1. Experimental design, recruitment and ethics

This investigation was a mixed, cross-sectional, nonrandomized controlled trial, involving two groups of participants, each comprised of first year occupational therapy (OT) students from the same class. All 125 OT students were invited and eligible to participate. This investigation was approved by the Research Ethics Office of Research and Innovation, University of Alberta, Canada. After inspection, this investigation was deemed ineligible to record participant sex variables, due to required de-identification of students to ensure their privacy.

2.2. Experimental process

VR was open-access to all students and self serve. This investigation utilized class email announcements to offer scheduled VR session appointments. Those who accepted the offer were designated as YesVR participants, with scheduled VR sessions taking place three-days before the OSCE. After the VR sessions were complete, a class email announcement was sent out to invite all students to complete online surveys, measuring student state anxiety and trait test anxiety levels. Students who reported to have not used the VR simulation, yet chose to complete the surveys, were designated as the NoVR group. Semi-structured focus groups and interviews were scheduled after the students completed their OSCE, within a one-week timeframe.

2.3. The anxiety surveys

The State-Trait Anxiety Inventory (STAI) is divided into two forms: Y-1 (S-Anxiety) scale, which this investigation used to measure each participant's level of anxiety at a specific moment in time. The STAI also contains the Y-2 (T-Anxiety) scale, which is used to measure generally trait anxiety, yet this form was substituted for the Test Anxiety Inventory (TAI) as this instrument measures trait test anxiety levels in academic contexts. Each form is comprised of 20 items, with final scores ranging from 20 to 80, with higher scores representing greater levels of their respective anxiety types (Spielberger et al., 2015).

2.4. Interviews and focus groups

Questions focused on how student overall experiences, expectations, difficulties, stressors and VR influenced their performance in the OT program. Interviews took up to 45-minutes in duration while focus groups lasted 60-minutes. Interview and focus group data were summarized using an interpretative thematic analysis, based on an approach developed by Burnard (1991), interview process guide by Kvale (1996) (Kvale, 2007) and general approach by Maykut and Morehouse (1994).

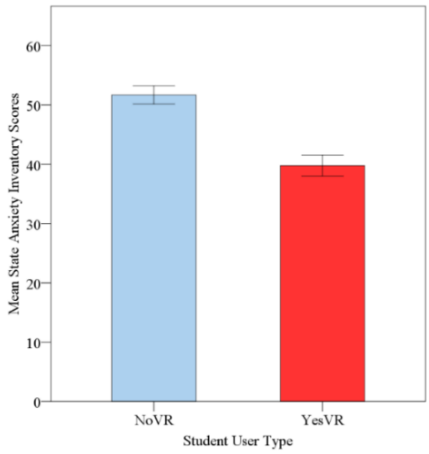
2.5. Simulation design

The VR simulation in this investigation included the following components:

1. Meta Quest 2 headsets that ran the VR software, uploaded using SideQuest. These headsets were portable and free of cables. The headset could detect a user's hand gestures, without the use of controllers. The headset was also equipped with a microphone to detect user speech for communicating with the virtual patients.
2. A virtual environment depicting a health sciences clinic, rendered with Unity game engine software (Unity Technologies). The environment allowed the student to select from one of two modules: History Taking or the St. Louis University Mental Status Exam (SLUMS) cognitive assessment (*SLU Mental Status Exam*). Once the student entered the virtual exam room, a buzzer sounded the start of the virtual OSCE and a miniature timer on a desk began counting down from either 8 minutes for the History Taking module or 15 minutes for the SLUMS module. Students could grasp and turn pages on a virtual clipboard to read notes. The History Taking clipboard contained preliminary notes about the virtual patient, similar to what the student would receive before interacting with their real-world OSCE standardized patient, while the SLUMS clipboard contained a scoring rubric and question sheet. Refer to Figure 1 for a screenshot of the History Taking module.
3. Three virtual avatars. The first appeared in the history taking module as a virtual standardized patient who would respond to a user's questions; the second appeared in the cognitive assessment module as a virtual standardized patient, who would respond to user questions from the SLUMS cognitive assessment; the third being a virtual exam evaluator (present in both modules) who observed the user and would write notes into their clipboard during each module.
4. Speech recognition and response software using Azure Cognitive Services. The student could ask the virtual patient questions in natural language, with the user's voice being detected by the headset's microphone to convert the question from speech to text. The process pipeline includes user speech-to-text, open artificial intelligence for language processing and generation of virtual avatar's text response, avatar's text converted from text-to-speech. The virtual standardized patients' text responses were generated using a generative pre-trained transformer (GPT-2), which was fine-tuned (ie, trained) on recorded interactions from real-world student and patient actor interactions during real-world lab exercises. This avatar training was performed using a transfer learning technique using real-world student and standardized patient text files that were collected from transcribed recordings. GPT-2 uses word vectors and input, producing estimates for the probability of the next word as outputs. It is auto-regressive in nature: each token in the sentence has the context of the previous words. Virtual avatar actions (behaviors) were generated in text form by GPT-2 then linked to appropriate animations (movements), allowing them to respond to user requests (eg, drawing pictures when asked to do so during the SLUMS module).

Figure 1. Screenshot of History Taking module.

Figure 2. Student state anxiety between groups; error bars represent standard error. NoVR: subjects not exposed to the virtual reality simulation; YesVR: subjects exposed to the virtual reality simulation.



2.6. Statistical analysis

Statistical significance was evaluated at α=.05, and a two-sided P value of .05 or less was considered to be statistically significant. Comparisons between the NoVR and YesVR groups were performed using independent *t* tests, which compared STAI and TAI scores between the groups.

3. Results

A total of 108 students participated in the quantitative aspects of the study (mean aged 24.53 years, *SD* 2.64): 61 for the NoVR group (mean aged 24.52 years, *SD* 2.42) and 47 for the YesVR group (mean aged 24.54 years, *SD* 2.93). A total of 25 students participated in the interviews and focus groups – 16 from interviews and 9 from focus groups. The majority of YesVR participants utilized the VR simulation for both modules, which typically meant 8-minutes of the History Taking module and an additional 15-minutes with the SLUMS module, in addition to some participants retrying one or both of the modules. The mean VR simulation time spent by the YesVR group resulted in a mean VR simulation time of 24.11 minutes (*SD* 8.00) per participant.

3.1. The anxiety scores

Figure 2 shows student state anxiety scores between the NoVR and YesVR groups. There was a significant difference in state anxiety scores between groups, with NoVR showing greater anxiety scores (mean 51.69, *SD* 11.87) than YesVR (mean 39.79, *SD* 12.21) (t_{106}=5.10, *P*=<.001, Cohen *d* = 0.99). The mean difference was 11.90 units (95% CI 7.28-16.53). There was no significant difference in test anxiety scores between groups, with NoVR showing similar anxiety scores (mean 46.66, *SD* 11.15) to YesVR scores (mean 43.28, *SD* 11.58) (t_{106}=1.53, *P*=.128, Cohen *d* = .29). The mean difference was 3.38 units (95% CI -.985-7.74).

3.2. Interview and focus group themes

VR was cited as being useful in helping with student orientation of the exam procedure, while allowing students to fail and work through difficulties in a low-stakes environment. The major themes emerging from focus groups and interviews were overall student background, exam feedback, fear of the unknown, self-consciousness, and the exam environment. Refer to Table 1 for the major themes derived from the interviews and focus groups.

Table 1. Major themes derived from student interviews and focus groups.

Theme	Sample student quotes	Interpretation
Exposure and Background	"The OSCE[a] is quite stressful is because many of us have not done a practical exam like this."	Students claimed those with related clinical exposure may have lesser exam stress.
Exam Feedback	"…to get feedback was not always easy because there is only one instructor to how many students?". "VR[b] made us be more aware to ask simpler questions in the OSCE[a], because it would glitch if talked too much."	The majority of students recommended additional performance feedback be provided, especially for the VR[b] simulation.
Fear of Unknown	"I dreaded the [patient scenario] because you didn't know what you were going to get and the exam was new to me."	Students claimed they felt anxious of the OSCE[a], because they did not know what to expect.
Self-consciousness	"No one wanted to be known as the person who failed the OSCE[a]."	Students claimed they worried about being deemed incompetent by their peers.
Exam Environment	"I found [VR[b]] helpful. [It was] my first VR[b] experience. I got to see what the layout of the room would be like."	Students recommended the VR[b] have exam rooms mimic the actual test environment.

[a]OSCE: Objective Structured Clinical Exam.
[b]VR: Virtual reality.

4. Discussion

This study shows evidence of immersive VR's potential as a tool for reducing state anxiety in health science students, who are preparing for clinical practical exams. The interviews revealed the importance of VR's role in improving student familiarity with the exam environment. Improved familiarity in this manner may have reduced student feelings of uncertainty, thus reducing student state anxiety levels. VR allows for students to make mistakes and learn in a private environment, away from peer observation and criticism. Students reported that their most preferred feature of future VR designs is to receive exam feedback, during their clinical skill practice. The feedback may inform students of their degree of completeness of questioning procedures or wording of questions to improve attentional efficiency. Additionally, the students requesting the implementation of features, such as the ability to perform physical check procedures on virtual patients, was recommended in future VR design.

5. Conclusion

Intolerance for uncertainty may cause students to interpret ambiguous exam situations as precarious events, manifesting symptoms of worry, self-doubt and anxiety. VR simulation has the potential to improve exposure to the exam environment, reducing feelings of uncertainty, while improving their exam familiarization. One of the major themes found in this investigation is the need for increased student practice opportunities for new components of clinical practical exams, along with receiving unbiased feedback. The use of VR simulation can provide students with opportunities to practice and receive feedback in a safe environment, potentially leading to improved performance in real-world clinical settings.

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