# Chapter #27

# IMMERSIVE VIRTUAL REALITY AND ARTIFICIAL INTELLIGENCE TO PREPARE STUDENTS FOR CLINICAL EXAMINATIONS: DEFINITIONS AND APPLICATION

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**ABSTRACT**
This chapter explores the potential of virtual reality (VR) and artificial intelligence (AI) to reduce test anxiety in health science students. The chapter provides basic definitions of VR, AI, GPT and campus anxiety. The chapter describes an investigation which used a generative pre-trained transformer (GPT) to generate responses from virtual patients in a virtual clinic, allowing students to familiarize themselves with the clinical setting. The immersive VR simulation allowed students to practice for their clinical practical exams with history-taking and cognitive assessment modules. Results show that students exposed to VR had significantly lower anxiety scores compared to those who did not use it. Interviews and focus groups revealed themes related to student background, exam feedback, fear of the unknown, self-consciousness, and the exam environment. The study highlights the potential of AI-enhanced VR as an effective tool in increasing student familiarity with clinical exam environments and reducing test anxiety.

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

## 1. INTRODUCTION

This chapter will briefly define immersive virtual reality (VR), artificial intelligence (AI) and demonstrate how these technologies can work together to supplement student learning in post-secondary health sciences. VR can enhance learning experiences by providing immersive and interactive environments (eg, simulated environments depicting a student's clinical setting during patient evaluation), allowing students to familiarize themselves with complex decision-making situations and user inputs. AI in VR simulation is capable of utilizing real time information to improve student adaptability while simulating complex scenarios (Loftus et al., 2020), as well as improve the expressiveness of AI-driven virtual patients during history-taking exercises (Maicher et al., 2023). AI-powered adjustments can be implemented to personalize virtual environments for students, based on their learning patterns and preferences, leading to more effective learning experiences (Loftus et al., 2020). AI-powered learning platforms can analyze student data, learning patterns, and engagement levels to optimize learning experiences.

## 1.1. Virtual Reality Defined

VR refers to a range of computer-based applications often utilizing visual and immersive 3D characteristics, allowing users to navigate and explore a simulated environment that appears to be real (Lioce, 2020). VR is also defined as a human-machine interface that allows users to project themselves into a computer-generated virtual environment, where specific objectives can be achieved (Zhang, 2014, p. 2427). The specific features of a virtual reality experience are typically determined by the technology employed, including head-mounted displays, stereoscopic capabilities, input devices, and the degree to which various sensory systems are stimulated. *Immersion*, *interactivity*, and *imagination* are the three key components of VR (Concannon, Esmail, & Roduta Roberts, 2019, 2020; Rebelo, Noriega, Duarte, & Soares , 2012). Immersion determines how a user perceives the virtual environment around them, ranging from nonimmersive (e.g., desktop computer display) to fully immersive (e.g., head-mounted display) (Rebelo et al., 2012). Interactivity is the accuracy between a user’s action and applicable response within the virtual environment (Rebelo et al., 2012). Imagination is the degree a user feels they are existing within the virtual environment (Rebelo et al., 2012). *Presence* in virtual reality refers to a user's psychological sense of understanding, knowing where they can move and interact within the virtual environment. The degree of presence experienced by an individual is subjective and is influenced by the level of *involvement* (ie, level of attention they feel) while engaging with virtual objectives. These components represent a VR’s level of *fidelity,* which is the degree a user’s actions, senses and thought processes within a virtual world represent those of the real world. For this chapter, the focus will be on immersive VR, which is achieved by head-mounted display units.

## 1.2. Artificial Intelligence Defined

AI is based on computer science disciplines, which involves the design and development of machines and computer programs, capable of performing tasks that traditionally required human intelligence to complete. AI leverages algorithms and other mathematical models to simulate human decision-making and problem-solving processes, and is used in a wide range of industries to improve efficiency, accuracy, and productivity. AI typically falls under one of two types (Murphy, 2019; Sajja, 2021): those based on *capability* and those based on *functionality.* Functionality AI refers to a system designed to perform a specific task (eg, computer chess AI), including those with machine learning algorithms (Murphy, 2019). Capability AI refers to machine cognitive abilities including narrow, general or super AI (Sajja, 2021). These capabilities include natural language processing, deep learning and neural networks (Mikalef & Gupta, 2021). An example of a capability AI includes a generative pre-trained transformer (GPT), generative AI, which features a large language model used in natural language processing, utilizing deep learning algorithms to generate human-like text based on a given prompt or input (Radford, Narasimhan, Salimans, & Sutskever, 2018). GPTs use a neural network that has been pre-trained on a large amount of literature found on the internet. When a GPT generates text, the model uses this knowledge to select the most probable word to follow the previous words in the sequence, based on the probability distribution of words learned from the training data. This process is repeated for each subsequent word in the sequence, resulting in a coherent and natural-sounding sentence. For this chapter, the focus will be on GPT, which was used to generate virtual patient responses to student verbal inputs within a VR environment.

## 2. BACKGROUND

This experiment in this chapter is a replication study that builds upon a previous study by Concannon et al. (2020). The faculty professors noticed students were showing symptoms of test anxiety, while they were performing their clinical practical exams. The aim of the previous study was to help alleviate anxiety symptoms experienced by health science students as they prepared for their clinical practical exams. Concannon et al.'s (2020) investigation made use of head-mounted immersive virtual reality (VR) for one group of students to simulate the exam setting. This group showed significantly lower mean-state anxiety levels compared to the group that did not have access to VR. The VR simulation was designed to represent the history-taking interview aspect of the Objective Structured Clinical Examination (OSCE), allowing students to interact with a virtual standardized patient. The investigation did not gather student feedback on the specific benefits of VR. The following contents in this chapter sets the stage for the replication study, featuring the use of immersive VR and AI together to enhance the clinical practical exam experience.

### 2.1. 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* (i.e., 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, Gorsuch, Lushene, Vagg, & Jacobs , 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, Hetrick, & Parker, 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, Gagnon, Ladouceur, & Freeston, 1998). It is common for students to feel symptoms of test anxiety, when preparing for practical exams with uncertain elements.

### 2.2. 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). 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 (Concannon et al., 2019) (Concannon et al., 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, Johnson, & Rushton, 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, Rodger, Fitzgerald, & Gibson, 2017).

## 3. 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 the VR simulation and coursework to better understand their learning environment.

## 4. DESIGN

This investigation rebuilt the VR simulation based on the system mentioned in Concannon and colleagues' (2020) study (Concannon et al., 2020), utilizing the same interdisciplinary team members' expertise in computing science, physical therapy, communication and science disorders, rehabilitation medicine and OT. Student and researcher feedback from the aforementioned study was implemented to further improve the system used in this investigation. 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 a 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 AI 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.*


## 5. METHODS

### 5.1. 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.

### 5.2. 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.

### 5.3. 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 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).

### 5.4. 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) (Burnard, 1991), interview process guide by Kvale (2007) and general approach by Maykut and Morehouse (1994).

### 5.5. Statistical Analysis

Statistical significance was evaluated at $\alpha$=.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.

## 6. RESULTS

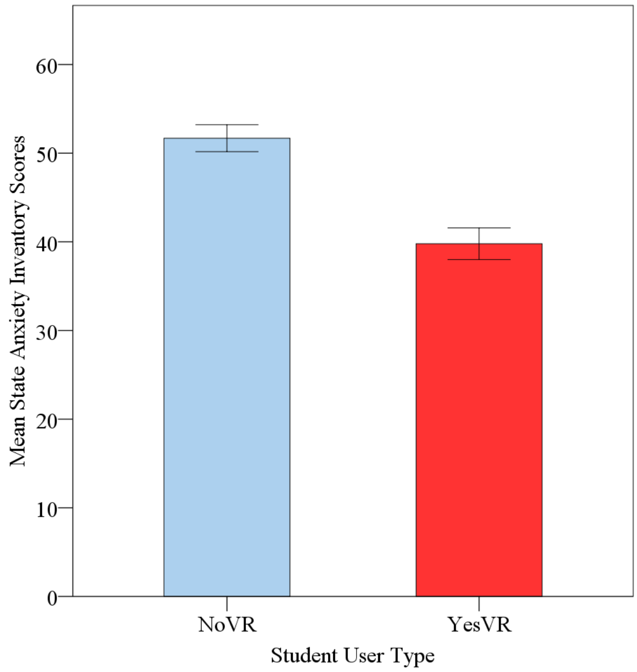
A total of 108 students participated in the quantitative aspects of the study (mean aged 24.53 years, *SD* 2.64): 61 for the NoVR group (mean aged 24.52 years, *SD* 2.42) and 47 for the YesVR group (mean aged 24.54 years, *SD* 2.93). A total of 25 students participated in the interviews and focus groups – 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.

### 6.1. 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).

*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.*




## 6.2. 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.

## 7. FUTURE RESEARCH DIRECTIONS

New components can enhance the VR simulators for reducing anxiety in health science students. Based on the student feedback provided in this investigation, having the VR simulation provide objective results, based on student performance, would satisfy the most requested feature as recommended by students. To ensure that the system provides only the necessary information for the students to enhance their learning ability, discussion between the designers, professors, and exam evaluators would be necessary for designing the system to provide the relevant feedback. The purpose of the simulation is not for students to exploit it (ie, game the exam), but to serve as a tool that aids in understanding objective parameters of their simulated practice, such as time spent with virtual patients on certain topics, total time taken, and the number of questions asked. Upgrading the GPT to its latest version and training it on real time interactions could improve virtual patient response continuity for specific scenarios in the History Taking module. GPT is also capable of giving the virtual patients personality, increasing a student's sense of imagination. Improvements in realism, including the availability of avatars from different cultures and backgrounds, can enhance the student's perspective of real-world clients. Allowing users to adjust the testing environment could improve the representation of the real OSCE environment, adhering to student preferences.

## 8. DISCUSSION

This research integrated immersive VR and AI systems to simulate clinical practical exams for health science students. The VR simulation in this research was designed to familiarize the students with the exam format, primarily for environmental settings and patient verbal interactions experienced during a student's actual OSCE. By practicing in a controlled VR environment, the students may have gained a sense of procedural confidence, showing a reduction in state anxiety. However, it remains to be seen whether this reduction in state anxiety persisted throughout the actual OSCE. This study did not capture student performance metrics, thus it is unknown if the VR simulation enhanced student performance for their actual OSCE.

The relationship between VR simulation, AI and the OSCE is based on enhancing the training of health science students. VR may replicate the conditions of an OSCE, with the VR in this research intended to familiarize the students with the exam format, setting and verbal interactions experienced during the actual OSCE. The interviews in this research identified a familiarity theme, with students admitting that VR was helpful in giving an idea as to what the exam room layout and procedures may entail. Intolerance for uncertainty may cause students to interpret ambiguous exam situations as precarious events, manifesting symptoms of worry, self-doubt and anxiety. However, VR simulation of the OSCE may have provided a sufficient familiarity with the exam environment, thereby positively shaping students' expectations and reducing their state anxiety levels. AI was integrated with the VR simulation to provide dynamic verbal interaction between the students and their virtual patients. AI was demonstrated to drive the behavior of virtual patients, making them respond in a communicative manner reminiscent of a real-world verbal exchange. The interviews in this research identified a theme from the students- their desire for the VR simulation to provide feedback based on their performance. AI has the potential to monitor student questioning in real time, possibly allowing students to review if crucial verbal exchanges took place or not.

To effectively evaluate student performance between VR simulation and the OSCE, it is crucial to develop metrics that apply to both settings. These could include metrics such as communication skills, decision-making abilities, procedural accuracy, and time efficiency. A standardized scenario framework is necessary to ensure that performances in VR and the OSCE are directly comparable. Objective assessment criteria must be consistently applied between both platforms to accurately reflect student proficiency. By ensuring that the VR and OSCE experiences are comparable, evaluators would be able to thoroughly assess how simulation-based performance translates to the OSCE context. Such comparative analysis is crucial for refining educational approaches while identifying specific areas where students may require additional training.

While VR and AI simulation may provide a valuable tool for conditioning students for clinical practical exams, VR differs from the real-world in several ways:

1. Physical Interaction: In a real OSCE, students interact with human patients in a complex manner (eg, physical checkup). Although it is feasible for VR to allow students to physically interact with objects and virtual patients, tactile feedback and nuances of human touch during such physical interactions are difficult to replicate in a VR environment.
2. Sensory Experience: In a real OSCE, the subtleties of smell, touch and sounds in a clinical setting may be difficult to replicate for a virtual setting. Even with enhanced auditory and peripheral senses, VR cannot fully emulate the richness of such real-world stimuli.
3. Emotional Dynamics: In a real OSCE, human patients may display a range of emotional and psychological states (eg, anger, frustration, depression) that can affect the examination process. While an AI simulator can show different emotions and personalities, it is unlikely to capture the full complexity of human emotional expression and how it impacts the patient-practioner interaction.
4. Unpredictability: In a real-world setting, patients may present atypical symptoms or responses (eg, people living with dementia), thus there may be limitations in VR and AI's ability to replicate such unpredictable scenarios.

5. Technical Limitations: VR and AI simulations are seldom an error-free experience. Glitches, system limitations and periodic updates may affect the flow and realism of the simulation. AI may provide immediate and objective feedback in real time, but it is expected to lack the subjective evaluation of a human examiner, which is often invaluable for student learning and professional growth.

However, a VR and AI simulation of a clinical practical exam may not need to be overly complex. The goal of such VR systems is to have students gain familiarity and feedback for an upcoming exam. The students in this research were in their first year of studies— they only needed a basic starting point. If students receive objective feedback on areas for improvement, during basic communication exchanges, they can focus on those areas to better prepare for the real OSCE. Both VR and AI may also check if certain decision-making processes occurred (eg, students scored the SLUMS psychometric correctly) and time spent on each task. AI can provide objective results and feedback on these parameters, which may be invaluable for students to understand their strengths and areas for improvement before they take the actual OSCE. AI enhances the VR simulation by providing a more realistic and interactive experience, which may lead to improved confidence and familiarity for the OSCE. AI has the potential to simulate a wide range of patient scenarios, while tailoring the simulation to the students' learning needs. VR and AI systems may bridge the gap between practice and real-world exams.

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