Feasibility of developing a 360° video-based virtual reality simulation of a stressful clinical event

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Abstract

Individuals early in their medical career feel unprepared for acute high-stress clinical situations such as managing a deteriorating patient. Simulation-based learning (SBL) is a method used within medical education to prepare for the clinical environment. SBL has been successfully integrated with virtual reality technology, however there is a lack of literature regarding its use for replicating the stress of a clinical environment and using 360° video to improve fidelity. Our non-specialist team aimed to develop and test the acceptability and feasibility of an interactive 360° video-based virtual reality simulation of a high-stress clinical situation. The simulation was developed within the ten weeks allocated to this project, however standardised measures from our sample could not be collected. Important information regarding the development and creation process was obtained and alpha testing of simulations were perceived acceptable and useful, thus, highlighting the merit of further research in this area.

Introduction

Newly-qualified doctors are likely to be exposed to a variety of physically and emotionally demanding incidents, some of which include witnessing death, violence, and aggression, and participating in resuscitation.[1,2] Factors such as emotional and physical distress are likely to elicit a physiological stress response, which may affect the performance of an individual in managing these situations.[3] It is widely accepted that an individual's self-efficacy is strongly linked with work-related competence and clinical performance.[4–6] Self-efficacy can be defined as an individual's beliefs regarding their capabilities to perform a behaviour or learn at a specific level.[7] Regardless of accuracy, an individual's judgment about their self-efficacy arises from several information sources including emotional state.[7]

Previous research related to clinical self-efficacy has indicated that many newly-qualified doctors feel unprepared as they step into their new roles, which are likely to involve managing stressful clinical events.[8,9] An example of such an incident would include the management of a deteriorating patient. A deteriorating patient can be defined as 'a patient who moves from one clinical state to a worse clinical state which increases their individual risk of morbidity, including organ dysfunction, protracted hospital stay, disability, or death'.[10]

Several studies have used self-reported questionnaires and interviews to investigate factors influencing a junior doctor's management of stressful clinical events. Concepts related to self-efficacy, such as clinical knowledge, technical and non-technical skills, have been investigated and identified that there was a significant lack of self-perceived competence and confidence among many junior doctors.[11,12] The acute stress elicited during stressful clinical events is identified in a study by Paice et al.[13] In this study, a sample of junior doctors were asked the open question, 'please think of a particularly stressful or difficult event that you have encountered during your house officer posts'. The most common response was an incident that involved professional responsibility beyond their self-perceived competence. The lack of preparedness for the role of a junior doctor has caused various mistakes in the past, some of which include delayed treatment, delayed diagnosis, amputation, and death.[14]

The literature highlights the issue that many newly-qualified doctors feel unprepared for common stressful clinical situations and that the emotional stress of certain situations may influence performance. Therefore, our current methods of preparing medical students for these situations may be improved to avoid the previously mentioned consequences.

A strong relationship exists between exposure to stressful events and confidence to perform effectively in these situations.[15–17] Improved practical skills and confidence are observed when junior doctors are engaged in bedside clinical training, while shadowing experienced doctors.[18,19] However, these experiences are often opportunistic and therefore cannot always be deliberately arranged. A widely accepted practice within medical education that allows individuals to have experiences akin to real clinical situations is via SBL. SBL is a practice that creates an artificial environment in which an individual can experience a representation of a real event in order to practice, test, learn, evaluate, or gain an understanding of human actions or systems.[20] Some of the various modalities of simulations include manikin based, computer based, and simulated patient based. The fidelity between and among these different simulation modalities tends to vary. Fidelity refers to the degree to which a simulation replicates the real events and/or workplace, and impacts the quality of the simulation.[21] SBL allows individuals to experience clinical situations, practice procedures or physical manoeuvres, and practice examination skills, among various other clinical situations.[22,23]

Studies suggest that SBL contributes to improved self-efficacy and performance, and eases the transition into clinical settings, along with improving patient safety.[24,25] Junior doctors have specifically emphasised the importance of simulation in acquiring knowledge and practising skills for acutely stressful scenarios, such as managing deteriorating patients.[26,27] Most medical simulations are developed in order to learn specific knowledge and clinical skills.[21] There is sparse literature regarding simulations developed with the aim of inoculating the stress that may be experienced during stressful clinical events.[28,29] However, the literature that does exist suggests that the development of such simulations may be useful in preparing newly-qualified doctors to better manage acutely stressful situations. Specific barriers to including such simulations may include operational challenges in developing and running simulations, such as resources, cost, and time. These barriers may be overcome by the utilisation of recent advancements in virtual reality technology.

Virtual reality uses an artificial digital environment in which the wearer can be physically immersed using devices such as head-mounted displays, and which can lead to the wearer feeling 'present' in the experience.[30] There are variations regarding the definition of virtual reality, however, most definitions highlight common elements. These are immersion in a virtual environment, a subjective sense of presence, and interactivity.[31,32] There have been recent advancements in virtual reality technology that have allowed for greater affordability, accessibility, and quality.[33] Virtual reality technology has successfully been integrated with SBL in various ways, some of which include training for laparoscopic skills, gynaecological procedures, and nasal endoscopy.[34] This integration allows for simulations to maintain the benefits of SBL, while simultaneously providing an opportunity to overcome limitations such as intense resource requirements and ongoing operational costs for repeated simulations.[35] Virtual reality can be used to improve the cost-effectiveness of SBL in medical education and may also be utilised to create high-fidelity simulations. These simulations can be used to better prepare medical students to become doctors capable of managing acutely stressful clinical events. This study aims to assess the feasibility of developing a 360° video-based virtual reality simulation of a stressful clinical event as an education tool for senior medical students.

Materials and methods

This project used a multimedia instructional design process, which involved identifying an appropriate scenario, creating a storyboard of the experience, recording the simulation with a 360° camera (Ricoh Theta S), editing the footage, developing an interactive simulation using a game development platform (Unity), and evaluating the acceptability of the simulation. We intentionally selected hardware and development tools that were affordable and commonly available as a test of their capability to create a viable simulation. The simulation context was designed for a final year medical student (trainee intern). After consulting with four physicians and a nurse, who each had more than four years of experience in managing deteriorating patients, we concluded that the management of a seizure on a minimally-staffed ward would be an appropriate and realistic scenario.

In this scenario, the trainee intern would typically call for senior support. There is a duration of time between calling for help and senior support arriving to where the trainee intern is responsible for managing the situation. In our chosen scenario, this duration was extended due to minimal staffing, which was believed to be a key factor in providing a stressful experience. Towards the end of the simulation, the trainee intern would be expected to give a verbal summary of events to senior support as they arrive. The verbal summary is common practice and another potential source of stress. The simulation would progress by the wearer interacting with the virtual environment to make decisions. We decided to use a non-linear structure to create a sense of realism and control, which allows the wearer to experience the consequences of their decisions. The non-linear structure creates complexity in maintaining the continuity of the narrative, as there are several branching avenues that could be experienced. To maintain adequate continuity and further develop the narrative, we initially created a storyboard within a Microsoft Excel spreadsheet, which contained information on each scene such as scene description, dialogue, interactable objects, and the branching scenes that can be triggered. We had difficulty assessing the continuity of the narrative within the spreadsheet format and therefore developed a flow chart using the open-source software Mermaid (https://mermaidjs.github.io), to better visualise the process and assess the flaws within the storyboard. The flowchart and the spreadsheet had been revised several times with consultation from physicians and nurses to improve clinical accuracy and continuity flaws.

The footage was recorded using a Ricoh Theta S camera. It was essential for us to understand the capabilities of the technology available in order to capture high-quality footage. We elected to record 360° video, rather than developing a virtual reality model of the simulation, for practical reasons. This development approach required much less time and we thought might also enhance the realism of the simulation. We tested recording footage from a variety of camera positions in order to assess the location where the footage best simulated a first-person experience. These test shots were also analysed to assess the field of view, distortions, and viable object placement. The camera also enabled us to capture four-channel audio, which allows for the sound to be mapped according to the virtual space during development.

With the permission of clinical and ward staff, we filmed the scenario in a ward room within Dunedin Hospital. Two medical students and a senior ward nurse had volunteered to act for the roles of patient, senior nurse, and junior nurse. We believed that their clinical experience would play a valuable role in creating a realistic clinical simulation. The footage recorded was then processed through the Ricoh Theta app and subsequently in Adobe Premiere.

The Vive headset can be used to experience a virtual world by viewing images through the head-mounted display. By using sensors, which track movement and subsequently modify the displayed image, the wearer is immersed within the virtual world. The setup also uses two controllers that are tracked and used to point and, hence, interact with the virtual environment. The simulation was built using the Unity game engine (http://unity3d.com/) and programmed using C# for logic control. Unity allows for videos of different stages of the simulation to be systematically linked together and triggered following interactions driven by the wearer.

Wearers interact with the simulation using the hand-held controllers. This involves pointing and then clicking on an object of interest (e.g. patient, blood glucose monitor), which then activates an opaque menu with options on how to utilise the object of interest. This allows for an array of interactable objects in which the wearer can decide to interact without being prompted. The interactions had consequences that either progressed the simulation to a new scene or provided feedback to the wearer through text within the virtual environment.

A training tutorial was developed to orient wearers to the virtual environment, and the entire simulation was piloted on three members of the research team. Informal feedback on early development versions (alpha testing) was gathered from a convenience sample of medical students.

Results

Our non-specialist team successfully developed a 360° video virtual reality simulation of a clinical event. We underestimated the time required for development, due to the difference between 360° VR and traditional multimedia design. This limited our ability to collect objective data within the ten weeks available for this study. However, important information about the process of developing such a simulation was discovered. We had determined a process for utilising Unity to integrate components of 360° video, interactivity, and virtual reality to create the simulation. Information about the virtual experience was also obtained during feedback from ad-hoc simulations during and post-development for alpha testing.

Anecdotal feedback from the three members of the research team who piloted the simulation suggested that it was successful in achieving a sense of presence in the wearer, and may have the potential to influence self-efficacy for managing clinical emergencies. Alpha testing was done with four medical students with clinical experience and six medical students with no clinical experience. It was identified that students with no clinical experience seemed less likely to feel stressed or to feel more self-efficacious regarding their ability to manage the deteriorating patient. This is contrasted by the individuals with clinical experience who suggested a higher degree of stress and felt more self-efficacious. All individuals commented on the potential and usefulness of the simulation concept.

Discussion

This study has indicated that a non-specialist team can develop an interactive virtual reality simulation using 360° videos. These simulations can be made at a low cost and therefore, may ease operational issues associated with traditional simulation-based learning. Our results have suggested that these simulations may inoculate against stress, may influence self-efficacy, and may be useful within medical education. Preliminary results suggest a degree of acceptability and feasibility, and therefore, justify further research in testing the acceptability and feasibility of this simulation concept. A formal evaluation of this simulation and its impact on stress and self-efficacy will be conducted by the research team in the future.[i]

i This study has been approved by the University of Otago Human Ethics Committee (ref 18/211)

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