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Virtual Reality Medical Training: A Non-Inferiority Randomised Controlled Trial of VR vs Face-to-Face Training

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Abstract

Objective: This study focuses on clinical training approaches and specifically on the use of virtual reality tools to improve training in the medical setting, with the aim to train for new skills and retain known skills by revising. The issue of skill fading over time, particularly in skill training settings, will also be addressed. The aim of this study is to investigate whether medical training with a virtual reality scenario can improve medical training and improve the issue of skill fading, observed in a period following the training sessions.

Methodology: A randomised controlled trial was conducted with medical students undertaking basic life support training. 78 second year medical students were randomised in two groups: (A) The control group which received the standard clinical training with the standard course materials following the completion of the clinical training for a duration of 1 month, and (B) the interventional VR group which received virtual reality-based clinical training with cardiac arrest scenario that was accessible on their smartphone for a month following the training. All participants underwent a test simulation on day 1- and 1-month post-training. The outcome of the test was assessed on the criteria of (1) number of correct clinical decisions and (2) time taken to achieve a clinical decision. In addition to the test, the students were asked to complete a questionnaire in scope of assessing their confidence or stress levels in performing life support techniques in the hospital setting while also reporting on their stress levels.

Results: Participants in the VR intervention group achieved a higher mean of correct clinical decisions when compared to the control group with a score of 6.8 versus 6.5 out of 8. The results from the second follow up test in the control group had better results, on average, when compared to the interventional VR group with a score of 7.4 versus 7.6 out of 8. In addition, it was observed that the confidence score increased while anxiety scores decreases. The mean time in making a clinical decision in 5 out of the 6 clinical decisions that were timed were observed to be faster in the intervention group and this result was also apparent in the follow up simulation at month 1. The VR interventional group had faster responses for clinical decisions (5 out of the 6 clinical decisions) in both the day 1 and month 1 following the tests.

Conclusions: This study identified that using virtual reality training in the clinical setting could improve the performance of students in both short term and long term with decreased anxiety.

Keywords: Virtual reality; Resuscitation; Smart phone; Virti; Medical education

Introduction

The World Health Organization estimates that by 2035 there will be an approximate 12.9 million shortage of health professionals and it is partly attributed to shortcomings in the execution, access, and quality of health professionals education [1]. From discrepancies in delivery to short teaching time frames, current forms of medical education render limited opportunities for physicians and nurses to become highly adept in various skills [2].

The gold standard method for training healthcare professionals has long been face-to-face training in simulation centres or in clinical environments. Although essential simulation training can require high time commitment from individuals to accommodate in their very busy curriculum, such as that of clinicians, and increasing clinical demands makes it more challenging for the scheduling and running of training sessions not only due to time demands but also due to the rising costs and pressures on the clinical faculties [3].

Novel, low-cost, and fast training methods emerged recently that may hold the potential to reach a much wider audience in a convenient and cost-effective way. Virtual reality training when paired with surgical hardware demonstrated benefits in surgery; however, there is a requirement for trainees to have access to surgical hardware and high-end virtual reality headsets tethered to a PC which ultimately causes inconvenience for trainees. A promising field for health professional training in terms of affordability and accessibility is virtual reality that is delivered with a non-tethered, portable headset or smartphone. The Virti app is an application that can be installed on a smartphone and by this the student has the opportunity to be fully immersed in an interactive virtual reality scenario. This smartphone application can be used in medical student training as they can use VR to aid and enhance simulation training. The Virti app technology has the potential to deliver a simulation course in scope of preventing skill fading.

Previous research has shown that a refresher course of basic life support (BLS) at six months allows students to retain their skills for one further year [4]; however, the timepoint of 6 months of the simulation courses are challenging to deliver mainly due to the financial aspects and time pressures on the faculty, the students, and the staff. Considering also the cost associated with running these courses, it was identified that skill fading particularly for resuscitation skills is very important as most practitioners' experience skill fade within 3 months [5].

Cardiopulmonary resuscitation (CPR) is mandatory and a prerequisite for doctors by the general medical council [6]. In medical training there is a growing concern on the lack of emphasis on this skill and the reinforcement of basic life support (BLS) skills in medical schools [7]. Over 60% of 4th year medical students lack in confidence in dealing with cardiac arrest situations [8] while over 35% of final year medical students were reluctant with low confidence to participate in resuscitation [9].

The principle aim of this study was to assess medical training delivered with a portable and affordable VR scenario and whether it could improve clinical performance, particularly of CPR, and reduce fading of clinical skillset, in a validated assessment study. The VR tool was also assessed on its impact on the confidence of the trainees to action the taught skills, when required, into practice.

Methods

In this noninferiority trial, the null hypothesis was that the VR training app is inferior to face-to-face training. We selected BLS as the standardised training content to assess the null hypothesis as BLS is mandated for all health professionals and has set steps and criteria for objective assessment which translate into clinical practice.

Aim of the study

The primary aim of this study is to compare clinical decision-making speed and accuracy between face-to-face BLS training and training using the Virti VR app.

Hypothesis

Our hypothesis is that training with the Virti VR app will result in performance scores and decision-making times that are non-inferior to those achieved by face-to-face training.

Population

Inclusion criteria were adults (≥18 years) able to provide informed consent and enrolled in the second year of a medical training course in the UK who had not completed or attended a basic life support training course or been exposed to basic life support principles in the past. Participants were excluded where there was any physical reason that they were unable to perform BLS steps for assessment (e.g. injury, physical impairment etc.).

Virtual Reality scenario production

A 360-degree video recording of a simulated in hospital cardiac arrest was produced which aimed to recreate the stress and emotion perceived in a real-life cardiac arrest, as closely as possible. The video was uploaded to the Virti web-based platform: The Virti platform allows a user to overlay computer generated imagery animations and voice instructions onto a 360-degree video. This technology allows teaching of instructions that are normally taught via traditional face-to-face CPR courses but with the benefit of being experienced in a VR setting. Information in the 360-video of CPR included prompting the student to call for help, instructions to how to perform CPR, how to deliver rescue breaths, and how to attach an automated external defibrillator (AED). The VR scenario and overlaid teaching instructions were reviewed for quality and accuracy by the resuscitation team at our institution.

Study design

We conducted a non-inferiority randomised control trial with 78 second year medical students.

Second year students were chosen as they had not yet been exposed to mandated BLS training, while exclusion criteria included having had formal BLS experience. The students were randomised in two groups using a computer-based randomisation programme. Participants were randomly allocated (1:1) to either A) certified instructor-led face-to-face training or B) VR training with the Virti VR app. The study flow chart is outlined in Figure 1.

The day following the training, all participants were assessed with a BLS skills test while the assessor was blinded to the study group. Participants demonstrated acquired BLS and automated external defibrillator (AED) skills during a specifically designed BLS scenario. We used a certified training manikin and overall CPR performance was scored with using the UK Resuscitation Council endorsed checklist, focusing on the required steps for performing adequate BLS.

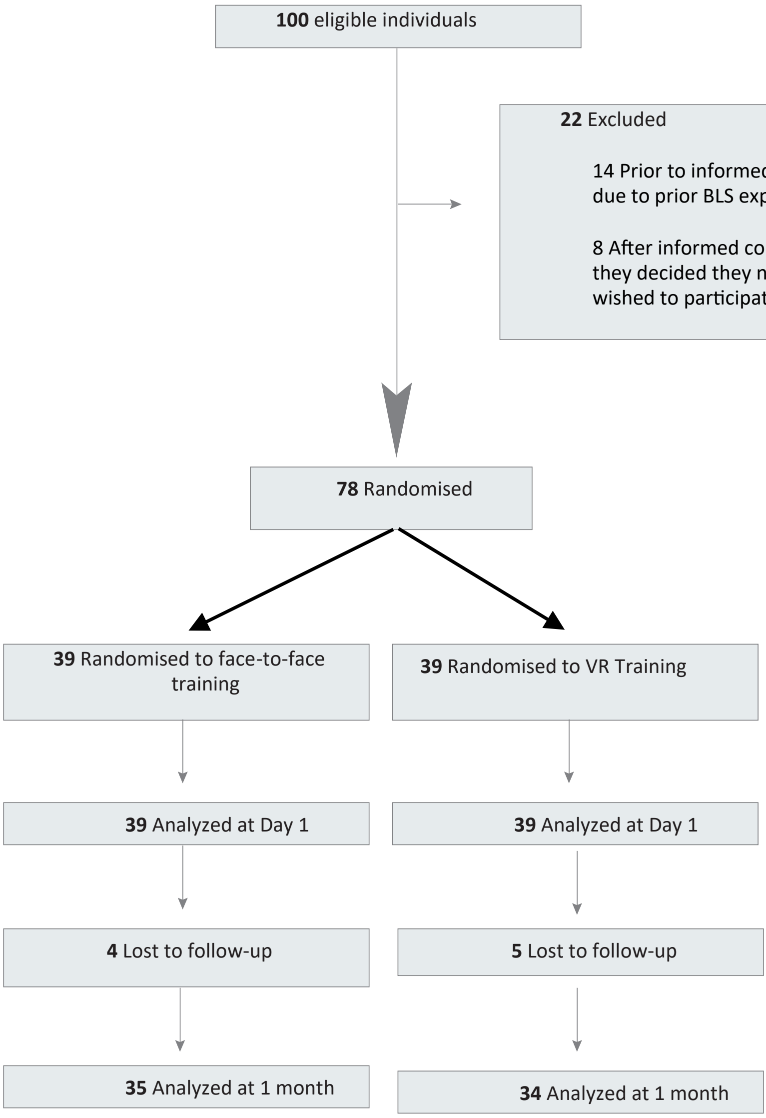

Figure 1: Study flow chard of the randomisation protocol

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The control group was taught a standard BLS course as prescribed by the UK resuscitation council while the interventional VR group only had access to the Virti VR scenario that was accessible free of charge and downloadable on their smartphones.

During the VR training, trainees were immersed in the filmed BLS scenario while wearing a portable, untethered Oculus Go VR headset, for approximately 15 minutes: Users were actively involved with the resuscitation of a patient experiencing cardiac arrest and were asked to take decisions, in a timely manner, in the virtual environment as the scenario unfolded. The app provided feedback on the decision-making processes, as well as core knowledge of BLS, such as chest compression depth, but also medications to prescribe AED use.

Following the initial training, the participants in the control group were provided with the standard post-course materials, including the UK resuscitation council recommended videos and written materials. Participants in the VR group were able to access the VR app on their smartphones for a period of 1-month post-training using the app on a smartphone: The VR app offers the advantage of interactivity and has the advantage to be used in the absence of a headset. Supplementary equipment included the use of a standalone Oculus Go Headset and Apple Smartphone, see appendix for in-game footage from the Virti app.

On day 1 following their initial BLS training all participants underwent the same assessed simulation scenario test which included the management of an unresponsive patient that was in cardiac arrest. All faculty assessors that marked the answers were blinded to the arm that the participant was in. Participants were assessed on their performance during the simulation while they also completed a questionnaire following their VR training.

At month 1, there was an additional assessment using a similar simulation scenario of cardiac arrest. In terms of accessing refreshing material, the control group received standard textbook and online post-course materials including video while the intervention group had continued access to the Virti VR scenario. Following the completion of the study, the control group were also given access to the Virti VR scenario. Ethical approval was granted by the University of Bristol Research Ethics Committee. All participants gave written informed consent to participate in the study.

Outcome measures

Primary outcome measures: Stimulation outcomes were assessed with 1) based on how many correct clinical decisions were made during the scenario, with a maximum score of 8, and 2) the time taken to take decisions over a period of 3 minutes.

Secondary outcome measures: Following, all participants were invited to complete a questionnaire in order to assess their confidence in performing the required steps of BLS, the level of stress and how it affected their performance, the effect of teaching approach on the simulation approach, and finally their confidence to perform BLS in a real-life situation. All students were asked to score their response on a Likert scale from 1 to 10.

Results

The study recruited 78 second year medical students that were not previously exposed to BLS training and divided to two groups, a) 39 to the control group and b) 39 were randomised to the intervention group. All students were assessed on their performance while also completing a post-stimulation survey. Following the BLS training, the assessment undertaken in 1 month was completed 34 and 35 students in the intervention and control group, respectively while all attending students completed the post-simulation survey.

Quantitative results

In relation to the assessment process, the simulations were composed of 8 clinical decisions. Participants received a mark out of 8 depending on how many correct clinical decisions were made. The correct number of clinical decisions participants made during the initial and follow up simulations is shown in Figure 2: The intervention group achieved a higher average of correct clinical decision when compared to the control group: The intervention group averaged 6.8 correct answers versus 6.5 in the control group. All students had improved performance with no statistically significant difference between groups. Adding, the mean times to clinical decision out of the 8 clinical decisions during the test simulations are shown in Table 1. The mean time to clinical decision was faster in the VR intervention group while the follow up simulation mean times in 5 out of the 6 clinical decisions were faster. In the control group, it was observed that in the follow up assessment, the "call for help" had the fastest response.

Questionnaire results

The average scored response of participants for each question following the first simulation assessment is shown in Figure 3: It was observed that the interventional VR group scored higher in their confidence levels on both the performance of BLS but also on the confidence to perform BLS in a real-life situation. It was also reported

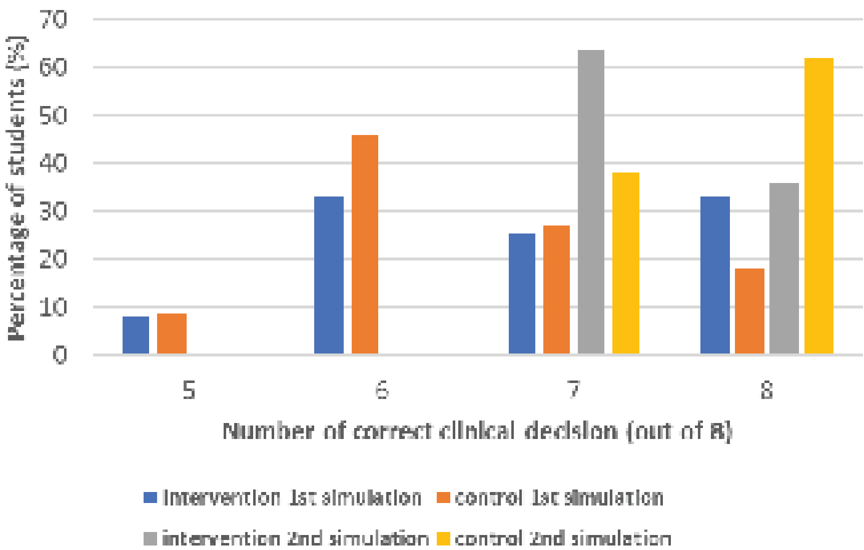
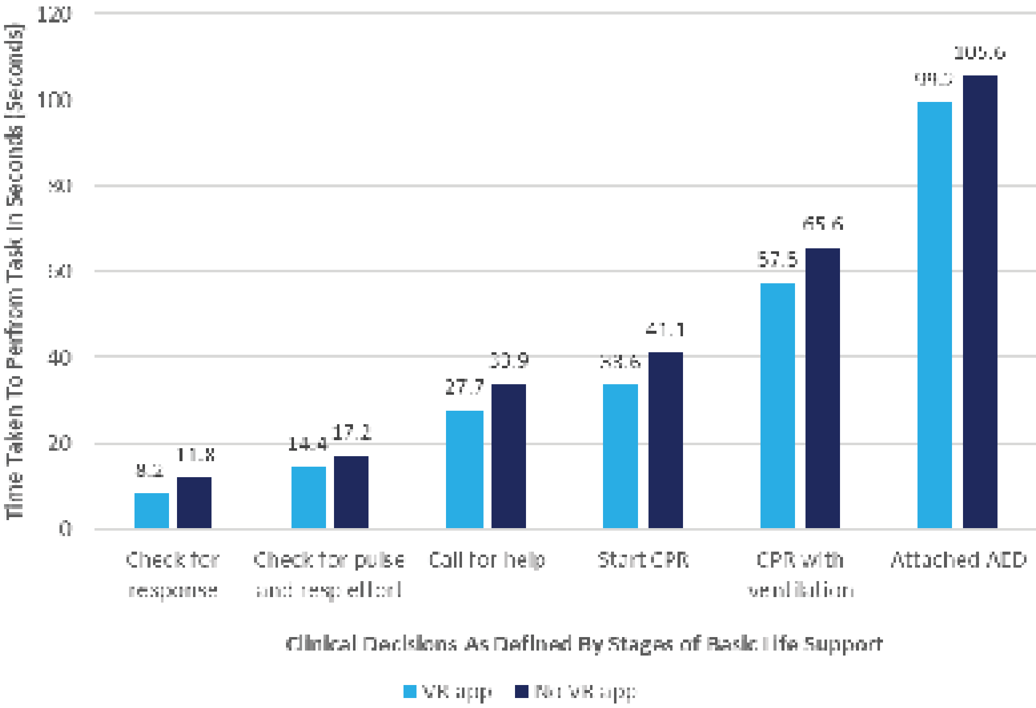


Figure 2: Correct Clinical Decisions.

Table 1: The mean time (seconds) to clinical decision in the two groups.

Clinical decision	No VR app 1st simulation (n=39)	VR app 1st simulation (n=39)	No VR app 2nd Simulation (n=35)	VR app 2nd simulation (n=34)
Check for response	11.8	8.2	7.5	6.3
Check for pulse and respiratory effort	17.2	14.4	10.75	10.5
Call for help	33.9	27.7	23.1	26.1
Start CPR	41.1	33.6	24.6	22.2
Start CPR with ventilation	65.6	57.5	46.3	44.6
Attached AED	105.6	99.2	68.6	63.7

Table 1 as a Figure: Time Taken (in seconds) To Take Appropriate Action During the Assessed Simulation.



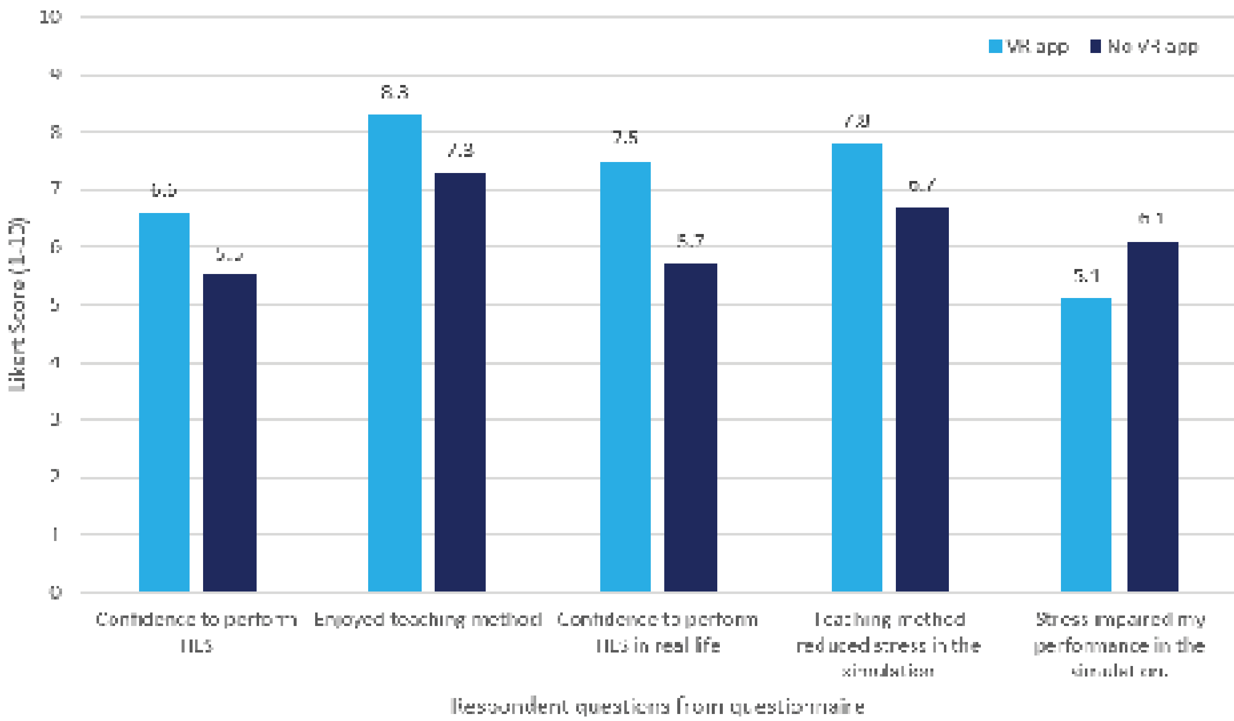


Figure 3: Likert scores from questionnaire following Day 1 assessment simulation.

that the participants enjoyed the interventional VR teaching approach more with higher statistically significant result (p=0.02). Adding, the participants in the interventional VR group had reduced stress levels during the first VR simulation, resulting in better performance.

Figure 4 shows the average scored response for each question asked in the questionnaire after the follow-up simulation assessment. Participants in the interventional VR group had better confidence in performing BLS in the exam and real-life when compared to those in the control group. Both groups reported that the follow-up simulation was perceived more stressful which influenced their performance. Notably, the interventional VR group reported that they had decreased knowledge to a greater extent than the control group.

Discussion

Providing clinical training to medical practitioners can be challenging due to time constraints, cost and trainees and trainer's availability. New approaches emerged to overcome these obstacles such as training with virtual reality tools: This study was performed to assess the efficacy of using a VR scenario to improve clinical training and decision making and increase confidence when performing BLS assessed in a test simulation with the aim to be trained for a real-life setting.

The study found that the students that received training with the Virti app had better performance in their initial assessment on clinical decision making in considerably less time than the control group. This pattern was also repeated in the follow-up assessment, at month 1 post the initial BLS training.

Participants of the interventional VR group had greater confidence that was directly related to the obtained methodology and knowledge obtained on the BLS steps as well as in performing BLS in real-life: Student's answers to the questionnaire confirmed this fact, while they also reported that using VR to learn was an enjoyable teaching method when they compared it to standard teaching approaches, such as those experienced in the control group. This result was also confirmed in the follow up assessment of the VR group as they felt that their confidence in performing the steps of BLS was higher than the control group. Noting, the VR group expressed that they felt more stressed during the follow up simulation when compared to the control group and that this outcome in parallel to the drop in their knowledge may have impacted on their performance. Despite this fact, it can be assumed that this was a result of being exposed to a new teaching method as importantly they performed better in the follow up simulation when compared to the control group. It can be assumed that the VR interventional teaching is superior to the standard BLS training as those in the interventional VR group have moved up the hierarchy of competence [10], from unconscious incompetence to conscious incompetence.

Limitations

Limitations of this study include the short follow up time period post training (1 month) due to the restraints of the tight curriculum and timetable gap between the participants initial training and the follow up simulation. Evidently, practitioners have fading of their skills within 3 months [5]. Due to the nature of the intervention, participant blinding was not possible. Research is on-going with this cohort of trainees to observe skill fading in a period of 12 months post training.

Future application

The use of VR as a training tool to learn mandatory skills and reduce skill fading is one of the many uses of VR in healthcare education. As this study suggests, VR can potentially be used to improve resuscitation training and improve a health practitioner's performance particularly in stressful situations and when under pressure; however, more research is required. The use of VR as a teaching tool is not just limited to teaching resuscitation skills; it is likely to have many applications teaching clinical skills, as well as being used as an assessment tool such as to assess how practitioners perform under pressure prior to exposure to the clinical environment. Fully immersive VR may be effective at improving confidence and decision taking under pressure, leading to reduced medical error and therefore improved patient safety.

Conclusion

This study suggests that virtual reality can positively impact the performance of clinical trainees in the short term. This is on-going research and results are currently being generated for observing outcomes in the longer term. Reduced stress level was also observed in the participants when engaging with VR teaching methods. Students also reported increased confidence to perform their acquired skills in real-life situations. Concluding, this study confirms that immersive VR scenarios, that offer ease by remote accessibility, can enhance learning of resuscitation skills and reduce skill fade.

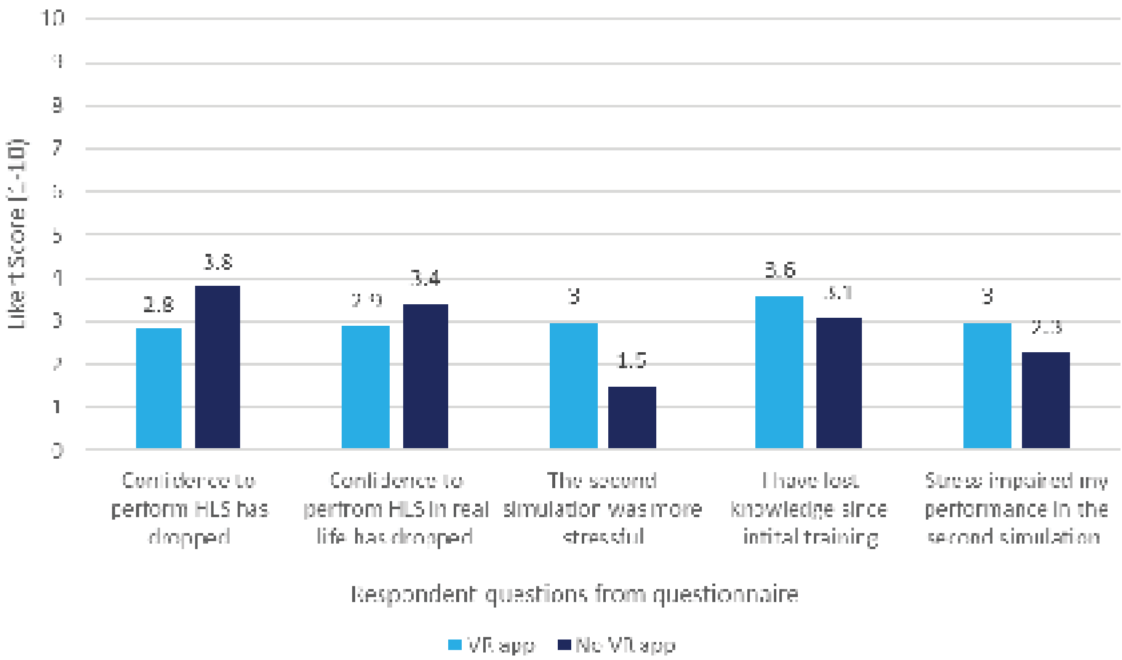


Figure 4: Likert scale scores from questionnaire after 1-month follow-up assessment.

Glossary terms

Virti is a company that develops and distributes immersive education for healthcare, and it focuses on developing accessible virtual and augmented reality apps.

Funding

All consumables were provided by Virti.

Conflict of Interest

Nil, Virti have had no input into the planning or running of this study and no investigator will have a financial gain in the outcome of this study.

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Ethic Approval

Ethical approval was gained from the University of Bristol ID: 65542.

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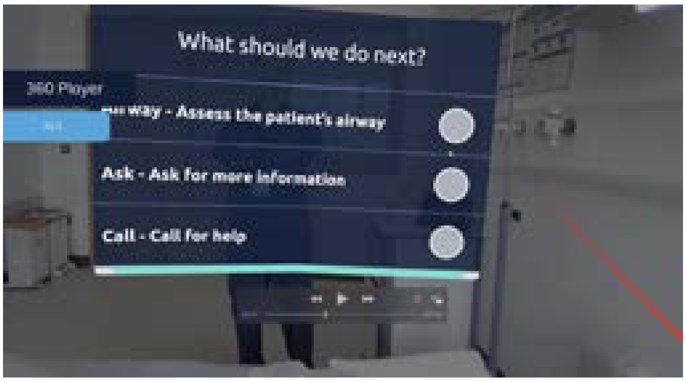
Appendix

i. Interactive decision choice tree and count-down.



ii. Screenshot of CPR and AED.

iii. Student using Oculus Go Headset.

iv. Virti Mobile App.