Lead author Mrs. Julia tod Senior lecturer CYP (Children and Young People) Nursing
Cardiff University todj1@cardiff.ac.uk

Mrs. Angharad Barklam lecturer CYP nursing
Mr. Nelson Selvaraj lecturer Adult Nursing
Mr. Peter Smith Technician – Simulation and Clinical Skills

We declare this submission is our own work and any additional sources of information have been correctly cited.
No conflicts of interests to be declared

Using Virtual Reality in Medicine Management Education

Abstract

Medication management is an important clinical skill that requires a problem-solving approach in the way it is delivered in undergraduate nursing programmes . Innovation in technology has offered some useful methods of educational development. In this article, we evaluate a virtual reality teaching session and how it was developed.

Key words medicine management, virtual reality, children's nursing, undergraduate education.

5 key points

Medication errors are a persistent challenge to safe practice in children's nursing

Emerging technology has a vital role in nurse education

Innovative medicine management teaching can promote reflection and engagement in the topic.

Simulated immersive experience replicates the responsibility of decision making for undergraduate students.

Technical support can allow creation of bespoke teaching resources fit for purpose.

Background

Medication error is a persistent challenge to safe nursing practice in children's care. Double-checking is believed to reduce errors (Marufu et al. 2022; Wesbrook et al. 2021; Koyama et al. 2020), and many hospital policies in the UK mandate this practice for most of the children's medicine (Marufu et al. 2022).

For student nurses this often means that they are either removed from the checking administration process or are 'third checker' with a limited sense of responsibility in the process. This lack of clinical practice experience could risk patient safety. Marufu et al (2022) in their systematic review identified interventions such as medication safety education incorporating simulation can reduce medication errors. Our projects aim therefore was to develop engaging simulated experience in medicine management teaching.

In a study exploring paediatric nurses' adherence to double checking, Alsulami et al (2014) highlighted a variation in practice. The complexity of the stages of checking and the importance of independent drug dose calculation in children's medicine management was identified as a key skill for nurses to develop. Another key area of development need was error recognition. It is known that more than one factor contributes to medication errors (Marufu et al 2022). The Swiss Cheese model illustrates how errors can occur when several safety checks fail with each 'hole' representing a potential error. When safety mechanisms fail, the holes line up, leading to an increased risk to a medication error occurring, affecting patient safety (Wiegmann et al. 2022).

Simulation has become an increasingly important teaching and learning strategy and allows health care students to make decisions and reflect on their practice (Tang et al 2020, Flott et al 2016). Virtual Reality (VR) can provide students with a memorable and immersive experience that would otherwise not be possible. Meta analysis of VR education has shown it can improve nursing students' knowledge and is equal to other

education methods in the measures of confidence, and performance time (Chen et al 2020). The use of VR has also been shown to improve clinical reasoning skills (Sim et al 2022). VR technology is becoming increasingly affordable, and we had access to equipment that would allow us to 3D film scenarios and create real life clinical situations for the students learning. The benefit of us creating content was that it would be specifically tailored to clinical procedures in children's nursing clinical practice, something that is not readily available in commercially created content.

Project development

A rapid shift to digital teaching and learning was inevitable during the COVID-19 pandemic, and many academic schools within Cardiff University adopted simulated methods such as VR in their curriculum delivery during this period. Within School of Healthcare Sciences, the traditional way of delivering skills and simulation-based sessions in a classroom or simulation setting was affected by social distancing measures imposed by COVID-19, creating barriers to effective teaching delivery and changing students' learning experiences. Since the publication of the emergency standards for pre-registration nursing programmes, which stipulated that the flexible use of up to 300 hours within a simulated learning environment would continue to be accepted (Nursing and Midwifery Council (NMC), 2021), we as lecturers have been constantly exploring various avenues to deliver skills and simulation-based sessions in innovative ways. Incorporating immersive technology such as VR in nursing curriculum has been found to be valuable for student learning and may affect patient care positively (Brown et al 2023). The unique advantage of VR-based learning is that it provides immersion into situations that are impossible or difficult to replicate in traditional teaching methods (Chen et al 2020). Other notable benefits of VR in education are that it can provide cost-effective solutions (Tang et al 2020) and enhance collaborative learning (Jochecova et al 2022).

It is well known that critical understanding of learning theories and how students learn is crucial for developing effective pedagogical approaches (Hamilton et al 2021), and evidence suggest that these theories can provide educators with a pedagogical framework which can enable them to design effective VR-based learning experiences (Marougkas et al 2023). Taking this into account and to improve students' learning experience, a project team comprising of three nursing lecturers and a simulation technician was appointed to develop storyboards and design medicine management scenarios. The overarching aims were to:

- Provide students with immersive learning environments that simulate real-world experiences;
- Facilitate learning through problem solving.for the creation of medicine management scenarios.

The approach of 'Learning through Problem Solving' is not new to nursing curriculum and it emphasizes the use of real-world problems to teach students new skills and knowledge (Marougkas et al 2023). VR can enhance this approach by providing an immersive and interactive environment that allows students to apply critical thinking and decision-making skills to solve real-world problems (Sedlak et al 2022). Therefore, the team felt that the use of the 360-degree immersive video technology was right for this project as the aim was to provide students with a level of realism and authenticity. In addition, with the 360-degree video scenarios, students can be brought into an immersive space where they can follow a patient journey or engage with the day-to-day activities of a ward and pause at relevant points to check their knowledge and understanding before continuing to the next activity. As there were children involved in the filming, a risk assessment was carried out and relevant proforma completed prior to the filming process to follow university's health and safety regulations and formal consent was gained from parents. This was the first project of its kind within the School of Healthcare Sciences at Cardiff University.

Three scenarios written and scripted by the project development team and relevant to the care of children were filmed using a chest mounted 360-degree video camera, giving the viewer the point of view of the nurses in practice and adding to the viewer's immersion. The camera was worn by the lecturer ‘actor’ who practiced the reduced walking speed required to manage camera ‘wobble’. The scenarios were filmed in a simulation suite and the activities were simulated but based on current clinical practice. The 360-degree video camera uses dual lenses to capture a full view of a scene. During the editing process, images from each lens were then ‘stitched together’ and edited by the simulation technician to generate a coherent 360-degree environment. Appropriate still images and supplemental information have also been incorporated within the 360-degree environment to highlight areas of interest and to aid navigation within the environment, for example images of a prescription chart. Following the editing process, these scenarios were uploaded to the VR headsets to create the experience of being inside the simulated clinical environment.

The first VR scenario was about a 12-year-old child whose antibiotic was administered to another patient. The aim of this scenario was to place the student in a situation where they could recognise how multiple factors affect a drug error. The students saw how distraction, failure to follow procedure, peer pressure and emergency situations can all lead to an error situation. The students saw nurses taking prescriptions from 2 different patients to a drug preparation area, one for preparation and one for prescribing. The oral antibiotic was safely prepared but as they started to return to the patient a phone call distracted one of the nurses the second entered the bay with 2 drug charts and one medication and was called to an emergency situation and the parent administered the unattended incorrect medication to their child because the prescriptions had been carried together and their child's was on top with the antibiotic . In the debrief, they explored what had one wrong at each stage and factors that might contribute to unsafe decision making. They also discussed how to manage the situation when a drug error occurred.
The aim of the second VR scenario was to prepare students to manage a medicine refusal situation with safe and proper practice. In this scenario, an 8-year-old with acute asthmatic episode refuses to take the prescribed oral liquid steroid. They watched 3 activities

- The mother offers to administer the drug covertly in a milk shake
- A support worker suggests restraining the child to administer the drug
- Changing the method of drug delivery

During the debrief the students reflected on the implications of these situations and what would be best practice.

In the third scenario, the VR headset projects a routine drug administration round and displays the prescription of an antibiotic for a 10-year-old who has been admitted with an upper respiratory tract infection. This scenario enables students to spot the multiple prescription errors on the prescription chart and discuss its wider implications for practice. The overall expectation was that those taking part in the VR scenarios would be able to gain confidence in making the right decisions and escalating care accordingly, all within a safe environment.

Project Challenge

As no earlier proof of concept for the use of 360-degree video existed within the School of Healthcare Sciences, no funding was available for equipment purchases. The camera equipment available to the technician was of consumer grade and not ideally suited for the moving shots needed, owing to the camera's insufficient picture stabilisation features. Although every care was taken by the actor to avoid excess movement whilst wearing the chest mounted camera, there was some significant camera "wobble" evident in the final product. To eliminate the effect of camera movement the use of tripod mounted stationary cameras was considered but the first-person view of a chest mounted camera was felt to give the viewer the experience of seeing the scenario "through the nurses eyes", playing on the strengths of the technology.

No video editing software capable of processing 360 footage was available, with a time limited demonstration version of Apple's Final Cut Pro being used for the project. This software version limited the resolution quality of the final export leading to a lower quality final product. The lower resolution combined with the camera movement is believed to have affected the viewer's experience, leading to some reporting feeling nausea or "seasick".

Implementation

The VR scenarios were first successfully used within a second-year Children and Young People undergraduate nursing cohort as part of their year two skills & simulation-based sessions. A group of 5 – 6 students was timetabled to attend each session and there was a facilitator present in the room to support students' learning.

After the first greetings and briefing, students were recommended to take a seat in the room and asked to wear the VR headset and turn it on. The simulation technician was present during the session to deal with any technical issues and clarify queries. Students were recommended to pause the scenario and remove the headset if they experience motion sickness and any other side effects. The video included a 30-second scenario brief followed by a full run of 15 – 20 minutes 360-degree VR scenarios. Students, if they wish, can pause the scenario on certain points and take notes for the post-session reflection and debriefing.

Following the completion of each session, students were asked to reflect on specific questions (e.g.: How would you manage this situation? How will you explain why it is important to take medicine in this way?) in relation to the scenario they completed. This was facilitated as a group discussion. During the debriefing, students were given the opportunity to discuss what went well in each scenario, critically reflect on their learning, find knowledge gaps if any, and share their overall experience they had with VR scenarios. A feedback questionnaire was handed out to students to gather more formal feedback.

Evaluation and Feedback

34 Children and Young People nursing students completed the evaluation form for the first VR medication management session. The evaluation form consisted of six questions with Likert scale ratings as responses and a further four questions allowing students to supply free text responses.

(Table 1: responses of 34 students insert)

Likert scale rating questions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Overall, I found the session beneficial to improving my understanding of medication management	0	0	1	15	18
			(3%)	(44%)	(53%)
The use of VR headsets was beneficial to the session	1	1	4	14	14
	(3%)	(3%)	(12%)	(41%)	(41%)
Using the VR headset allowed me to gain the perspective of the nurse administering the medication	1	1	3	11	18
	(3%)	(3%)	(9%)	(32%)	(53%)
The scenarios used were relevant to practice	0	0	0	6	26
				(18%)	(76%)
Enough support was provided when using the VR headsets	0	0	0	5	29
				(15%)	(85%)
The feedback session provided me with the opportunity to discuss issues raised in the scenarios in more detail	0	0	0	5	29
				(15%)	(85%)

To gain further insight into the students' views, the following four questions were posed:

- What aspects of the session did you find useful?
- What did you like about using VR headsets?
- What did you dislike about using VR headsets?
- What have you gained from this session that will improve your practice?

Aspects of the session students found useful

The students liked having three different scenarios to view addressing various aspects of medicine management in children's nursing. Comments from the students included that the scenarios were authentic, relevant and relatable to practice. The scenarios reminded them of how easily things can go wrong in practice with one student commenting it developed their understanding of 'how things can lead to medication errors and what to do if this situation happens".

Students commented that using VR as a way of delivering the scenarios was useful to seeing the scenarios through the nurse's eyes. It made them feel like real observers. It allowed them to be immersed in the scenario which was found to be more useful than only talking through the scenarios. It "really helped to immerse myself in the scenario and understand from the nurse perspective".

The students also highlighted some technical benefits of using VR. Students found being able to work through the scenarios individually and at their own pace beneficially. Equally, being able to rewind, pause was also found to be useful. "Having the ability to pause and rewind was good to check errors and double check".

Following using the VR headsets, a debrief session was facilitated by lectures to discuss medicine management within the three scenarios. Each scenario was explored, with incidences and errors linked to relevant theory, guidance and frameworks. The students found this interactive discussion useful to reflect on the scenarios and to gain a better understanding of medicines management. It helped the students to name errors they may have missed, find opportunities during a scenario the error could have been avoided and finally, how to deal with the error. "The discussion at the end helped me understand the scenarios and gain a better understanding".

Likes

The students were excited and enjoyed having the opportunity to learn in a new, different, up to date and innovative way. They said that not only were the scenarios relevant to practice but also gave them the opportunity to experience the scenarios from a perspective they could not experience during placements. Overwhelmingly, the students liked the immersive feeling of the VR experience. They said it 'felt' real-life being able to look around, assess the whole area and view the scenario from the perspective of the nurse. Again, students commented on how they liked being able to pause and rewind the scenarios and that using VR helped them to concentrate and take in everything that was happening in the scenarios.

"The VR helped to make you feel you were in the scenario and made everything clear from that perspective".

Dislikes

Although students were encouraged to remove their headsets in between each scenario, to answer questions based on the scenario and write notes for the debrief session, the main complaint about using the VR headsets was the feeling of motion sickness and there was some image blur.

"Sometimes felt queasy better resolution needed”

Practice understanding gained

Following the session, the students reported to have gained improved knowledge and understanding of medicine management. They had a better understanding of how easily medicine management errors can occur and how multiple issues in a busy environment can lead to a greater risk of errors occurring. The students reported gaining an appreciation of the importance of fully concentrating during the process of performing medicine checks to avoid errors and minimize risk. Students also highlighted the importance of following correct procedure, having clear communication between colleagues and not assuming written information was correct. The students felt the session, using VR scenarios to recognize poor practice and then discussing good, evidence-based practice afterwards, helped them be more equipped for practice.

“Discussing the correct practices to carry out as a qualified nurse, understanding how to limit the risk of error”.

Lessons learned

Breaks from the headsets were important to reduce any discomfort. For students affected with motion sickness it was important to have the footage available on a laptop so they could still take part in the session and contribute to the debrief.

Issues of inclusivity must be considered, the material must be available for those who cannot tolerate the VR mask, and this was a simple video of the scenarios run on a laptop. Also, for students who require headwear in their daily life (e.g., turbans) will require extensions on the VR straps.

Inadequate filming equipment and video production software influenced final image quality, a factor that reduced viewer immersiveness. Since production on this project ended, funding has been granted to the technician’s team for the purchase of up to date 360-degree cameras, audio equipment and production software.

The team has plans to refilm the scenarios with updated equipment, and the experience gained will allow us to deliver a far more polished product, improving student experience. It will also provide an opportunity to film the scenarios in Welsh as well as English. As a University in Wales, we need to ensure that we work within the university’s Welsh Language Strategy, Yr Alwad/Embrace It (2021) by supplying resources to students who wish to complete part of the Batchelor of Nursing programmes through the medium of Welsh.

Conclusion

The use of VR-based teaching is fast growing in nursing education and the demand for new ways of learning will continue to grow. Judicious use of VR can enhance theoretical knowledge and help learners to recognise and narrow the theory-practice gap. Our experience shows VR could have the capabilities to prepare student nurse to identify stages in medication errors and respond to clinical decision-making with practiced confidence. Building on the success of this teaching development It is hoped that improved production equipment will allow the team to resolve issues highlighted by student feedback.

Despite the weakness raised the student voice supported the benefit of this method

finding the immersive experience of the scenarios and viewing it from the nurse's perspective extremely helpful. They also believed that the debrief allowed new thoughts and views to emerge.

Safe medication management will benefit from innovative teaching practice and in this article, we have aimed to explore how technology can help to improve undergraduate nursing education.

References

Alsulami Z et al (2014) Paediatric nurses' adherence to the double-checking process during medication administration in a children's hospital: an observational study. *Journal of Advanced Nursing* 70: 6, 1404–1413.

Brown KM et al (2023). Curricular integration of Virtual Reality in Nursing Education. *Journal of Nursing Education*. 62: 6, 364 – 373.

Cardiff University (2021) *Yr Alwad/Embrace It – Cardiff University's Welsh Language Strategy* https://www.cardiff.ac.uk/__data/assets/pdf_file/0007/2523283/WelshLanguageStrategy.pdf (accessed 10 July 2023)

Chen et al (2020) Effectiveness of Virtual Reality in Nursing Education: Meta-Analysis *Journal of Medical Internet Research* .22.9 10.2196/18290

Flott EA, Linden L. (2016) The clinical learning environment in nursing education: a concept analysis. *Journal of Advanced Nursing.* 72: 3, 501–13.

Hamilton D et al (2021) Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. *Journal of Computers in Education.* 8: 1–32

Jochecova K et al (2022) Geography Education in a Collaborative Virtual Environment: A Qualitative Study on Geography Teachers. *ISPRS International Journal of Geo-Information*. 11(3):180.

Koyama AK et al (2020). Effectiveness of double checking to reduce medication administration errors: a systematic review. *BMJ Quality & Safety* .29**:**7, 595-603.

Marougkas A et al (2023) Virtual Reality in Education: A Review of Learning Theories, Approaches and Methodologies for the Last Decade. *Electronics*. 12:13, 2832.

Marufu TC et al (2022). Nursing interventions to reduce medication errors in paediatrics and neonates: Systematic review and meta-analysis. *Journal of Pediatric Nursing*. 62: 139 – 147.

Nursing and Midwifery Council (2021) Recovery and emergency programme standards. https://www.nmc.org.uk/standards-for-education-and-training/emergency-education-standards/ (accessed 3rd July 2023).

Sedlak M et al (2022) Collaborative and individual learning of geography in immersive virtual reality: An effectiveness study. PLOS ONE. 17(10), e0276267.

Sim JJ et al. (2022) Virtual simulation to enhance clinical reasoning in nursing: a systematic review and meta-analysis. *Clinical Simulation in Nursing*. 69: 26–39.

Tang, K. S et al (2020). Augmented reality in medical education: a systematic review. *Canadian Medical Education Journal.* 11:1, e81–e96.

Wiegmann DA et al (2022). Understanding the "Swiss Cheese Model" and Its Application to Patient Safety. *Journal of Patient Safety*, 18:2, 119 – 123.