ORIGINAL RESEARCH

Holograms in nursing education: Results of an exploratory study

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ABSTRACT

Objective: The purpose of this exploratory and descriptive study was to evaluate the student experience of using the Microsoft HoloLens® headsets and the HoloPatient application (app) to perform a nursing assessment of Jerry, a life-sized hologram of a young man admitted to Emergency Department following a mountain bike accident.

Methods: *Setting:* The research was conducted in 2019 in a New Zealand School of Nursing. Participants were undergraduate (pre-licensure) students (N = 121) enrolled in a 3-year Bachelor of Nursing degree programme. The study was conducted before students went on their first hospital-based clinical placement. *Methods:* The researchers designed a tutorial that guided students through the first five steps of the clinical reasoning cycle (i.e., look, collect, process, decide, plan) and collect cues and information about Jerry's condition which worsens as he develops anaphylactic shock. Tutorials were conducted during the week immediately preceding the first clinical placement to assist students to develop clinical reasoning and nursing assessment skills.

Results: Data were collected via a post-activity pen and paper survey. Quantitative data showed that this technology enhanced learning. Thematic analysis identified 17 advantages of using holograms, including realism, a reduced level of self-consciousness, and better preparation for clinical practice. Disadvantages mostly related to technical projection issues such as blurry image quality.

Conclusions: These findings indicate that spending time carefully observing, and processing information provided via a hologram assisted novice nurses to develop clinical reasoning skills, thereby increasing readiness for the clinical setting.

Key Words: Nursing education, HoloLens®, Holograms, Clinical reasoning, Augmented reality, Mixed reality, New Zealand

1. INTRODUCTION

Providing students with opportunities to develop clinical reasoning skills before entering clinical practice is foundational to safe nursing practice. However, with factors such as increased competition for clinical placements, advances in digital health technology, pressure on teaching timetables etc., alternative methods of delivery are necessary to ensure students gain confidence in the development of their clinical skills.[1] Augmented Reality (AR) and Mixed Reality (MR) digital technologies using holograms are now considered an integral part of health professional practice simulation education.[2–6]

Nonetheless, little is known about the how these technologies can be used to develop clinical reasoning skills among student nurses. The purpose of this study was to explore how MR technology using Microsoft HoloLens® headsets and the HoloPatient application (app) can be used to assist the development of clinical reasoning skills among undergraduate (pre-licensure) Bachelor of Nursing (BN) degree students.

1.1 Augmented and mixed reality technology

Augmented reality (AR) often referred to as Mixed Reality (MR), refers to a set of mobile digital technologies that allow a three-dimensional computer-generated model in the

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form of a hologram to be overlaid on a real environment.[6, 7] These technologies provide an experience that bridges virtual and real-world, supplements reality, and have the potential to redefine how people interact with their environment.[7] They are widely employed in the aviation, construction, and manufacturing industries.[8] AR and MR technologies are also used in healthcare and medical education[9] in a range of contexts, e.g., to teach anatomic pathology,[7] to simulate 'real' clinical practice situations such as patient interviewing,[5] and in leadership development.[10]

In nursing education, MR provides an intuitive and enjoyable way of learning for today's digital natives.[5–11] Nursing Schools in Australia, New Zealand and the United States of America are using the Microsoft HoloLens® MR technology in Bachelor of Nursing degree programmes to assist the development of physical assessment skills, enhance understanding of anatomy and physiology, and to improve the knowledge, skill, and confidence of nursing students.[11–14] A major benefit of using interactive digital technology is that students take an active part in their learning which helps them to construct new knowledge and skills within their personal environments.[4] Research suggests that this constructivist learning approach improves student confidence, fosters the development of critical thinking skills, and is an effective

way for student nurses to develop assessment skills where there is no risk to patient safety.[9, 13–15] Furthermore, using a standardised digital 'patient' provides a consistent learning experience for nurses with the added advantage of them feeling less self-conscious about participating in a nursing simulation.[16]

1.2 HoloLens® and HoloPatient

Most MR devices use a headset such as Google Glasses or the Microsoft HoloLens® that projects a hologram into the users' physical environment. The HoloLens® 1 device is controlled by hand gestures in the air, using swiping or pinching movements like those made on an iPad or smartphone, or with voice commands.[10] The person wearing the headset can hear sounds via an internal speaker in the headset, see the hologram, walk around, and observe it from all angles. They can also 'air click' keyboard commands to view a vital sign display (see Figure 1). Others in the same environment can also see a live streamed hologram when it is projected onto a classroom screen. Since completing this study Microsoft has released Generation 2 technology which is a more comfortable HoloLens® headset and the company GiGXR has developed the HoloPatient app that can be downloaded onto a phone (see section 4.3 Future directions).

Figure 1. Students viewing Jerry through HoloLens® headset (authors' photograph, reproduced with permission)

There are 10 patient teaching scenarios in the HoloPatient app, each accompanied by instructor resources which can be followed verbatim or used later as a teaching and debriefing guide. Scenarios feature patient case studies such as 'San-

dra', a young woman with asthma, and 'Mr Littlejohn', an elderly man with pre-existing medical conditions admitted to Emergency Department (ED) following a car accident. Scenarios are produced by filming an actor playing the part

of the patient (see Figure 1).

This study used the Microsoft HoloLens® virtual standardised patient scenario for anaphylaxis featuring 'Jerry', a 32-year-old male mountain biker. Jerry progressively develops the symptoms of anaphylactic shock after being given an injection of penicillin to treat an infected laceration on his back. The anaphylaxis scenario is presented to viewers in three short film clips that are opened by the instructor in the following sequence.

• Clip 1-Jerry rings his call bell and says that he feels "funny". He has a mottled red rash over his body, most visible around his neck. He groans incomprehensibly, appears uncomfortable, restless, and repeatedly scratches himself. The wound on his back looks red and inflamed. Vital signs, seen on the accompanying monitor are blood pressure = 140/84 mmHg, respirations = 20 r/min, pulse = 92 b/min, temperature = 38.4°C.

• Clip 2-Jerry is more restless and further redness and itchiness of the skin is clearly visible. He is febrile, has elevated

respirations, pulse, and blood pressure due to the body's histamine response.

• Clip 3-Jerry is slumped in the chair, his speech is slurred, skin flushing, and itching has worsened. Vital signs indicate respiratory depression and shock (blood pressure=86/60mmHg, respirations = 9 r/min, pulse = 140 b/min, temperature = 38.4°C).

Figure 1 shows students observing Jerry in clip 3. He is slumped in his chair; he can be heard groaning and his vital signs are displayed on the bottom left of the screen image.

1.3 Clinical reasoning

Clinical reasoning is a problem-solving and decision-making process by which nurses "collect cues, process the information, come to an understanding of a patient problem or situation, plan and implement interventions, evaluate outcome, and reflect on and learn from the process".[17] There are eight steps or phases which in real-time are dynamic, often merge and sometimes are combined. Figure 2 shows the eight steps of the clinical reasoning cycle.
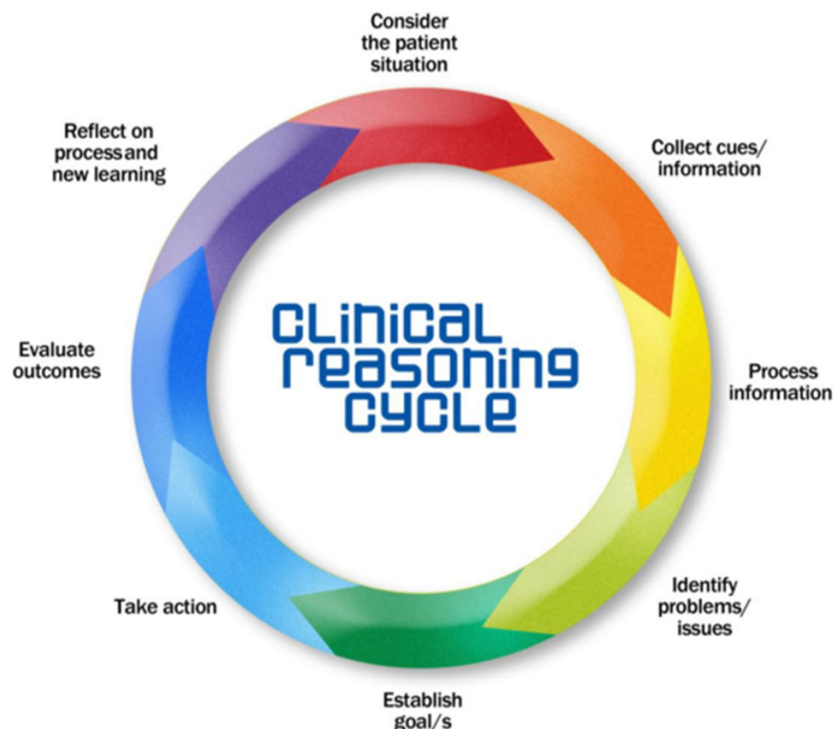

Figure 2. Clinical reasoning cycle[17]

The first step is to consider the patient situation.[17–19] This involves describing or listing the facts, context, objects, or people. In step two, looking and collecting cues/information; the nurse reviews current information, gathers new information and recalls related theoretical knowledge e.g., physiol-

ogy, medical conditions, etc. Step three involves processing information by interpreting, discriminating, relating, and inferring to predict an outcome. In step four, problems/issues are identified by synthesising facts to make a definitive diagnosis of the patient's problems. Selecting a course of actions

between different alternatives available is the fifth step. Acting, evaluating the effectiveness of action, and reflecting on the process and new learning (steps 6 to 8) complete the reasoning cycle.

Patient observation and collecting accurate information is critical to the provision of competent and safe nursing care and takes time to learn. It is also important for students to work through each phase, rather than making assumptions about patient problems or taking ill-considered and possibly dangerous nursing actions. Consequently, this study was designed to guide learners through the first five steps of the clinical reasoning cycle, emphasising the need for careful observation, accurate data collection, interpretation, and synthesis.

1.4 Research purpose and questions

The purpose of this research was to explore how HoloLens® MR technology can be used to assist the development of clinical reasoning skills among first-year nursing students. Two research questions directed this investigation.

RQ. 1 When using the clinical reasoning cycle to perform a nursing assessment for Jerry a) what cues and information did students collect, and b) what nursing diagnoses, and actions were suggested?
RQ. 2 What are the benefits and disadvantages of using holograms to teach clinical reasoning skills?

2. METHODS

2.1 Study setting and participants

The research was conducted in 2019 in a New Zealand School of Nursing. Participants were pre-licensure first-year students (N = 121) enrolled in a 3-year BN degree programme. The study was conducted as a clinical reasoning tutorial activity in a Human Behaviour theory course before students went on their first hospital-based clinical placement.

2.2 Ethical considerations

The study was approved by the institution's Research Ethics Committee (OPREC 2019-790). Information about the research project was posted on Moodle, the course Learning Management System two weeks prior to the scheduled HoloLens® teaching sessions. Although the clinical reasoning learning activity was part of the theoretical and nursing skill development course content, students were made aware that taking part in this study was voluntary. Students who agreed to complete an end-of-tutorial questionnaire signed a consent form and were assured that all responses would remain confidential. Verbal permission was also obtained in each tutorial session for the researchers to take photographs of students wearing the headsets. Written consent to use

some of these images in future publications was gained in a post-study follow-up tutorial.

2.3 Study procedures

The same 1-hour clinical reasoning tutorials were conducted by the researchers (the regular class lecturer/instructor and colleague who were supported by a Learning and Teaching IT specialist) four times during the week immediately preceding the first clinical placement for these students.

Each tutorial group comprised 25-27 students who were seated in five smaller groups. The instructors explained how to put on and use the headsets before allocating one to each group. A laminated colour diagram of the clinical reasoning cycle was given to each group for reference. Individuals then took turns to look closely at Jerry whose image was positioned on a chair at the front of the classroom. They were invited to collect as much information as possible from these visual and aural cues before removing their headset and returning to their group where they remained seated as the tutorial progressed. The instructor headset was worn by one of the researchers who advanced the scenario as groups finished their observations and note taking for the three clips. The time taken for all students to observe Jerry in rotation was 10-12 minutes per clip.

Information collected by group members during the activity was recorded on an extra-large sheet of paper divided into three sections: one for each clip of Jerry's medical scenario. Different coloured Post-it® notes were used for record keeping and learning: orange notes for cues and information (clinical reasoning (CR) steps 1 & 2), green for diagnoses deduced from the problems/issues identified (CR steps 3-5), and blue for proposed nursing actions (CR step 6). The worksheets were retained for future learning and a post-tutorial debrief session.

The process of collating information in this way meant that students could discuss Jerry's worsening condition in their groups. They could also identify problems/issues together before deciding upon and planning nursing actions. However, students were not briefed about Jerry's condition, as the researchers considered that this may have restricted their data gathering or biased their observational and thinking processes. Of critical importance, nonetheless, is that before advancing to Clip 2 in the scenario, students must have looked at Jerry's back to pick up the vital cue, the large wound on his back.

2.4 Research instrument

The researchers designed a short one-page paper survey to address the study questions. It contained the following statements and questions.

● Ten statements e.g., 'I felt confident about assessing the patient condition from the cues' rated using a five-item Likert scale that addressed student's perceptions of the overall learner experience (these are presented in Table 1).

● A short table in which to record up to three patient cues, problems/diagnoses, and nursing actions for each clip. The intention of using this table to record information was to assess after-class retention of information relating to the learning scenario.

● Open-ended questions about the clip students found most effective (circle one option), the overall learning effectiveness (yes/no response) factors that could be improved and the advantages and disadvantages (best and worst things) about using the HoloLens technology (open-ended questions).

The survey was pilot tested among a small group of second-year students (N = 35) who participated in a similar tutorial using a different HoloPatient scenario. Minor adjustments to the layout and wording of some questions were made to improve its usability. The time taken to complete the survey was approximately 10 minutes.

2.5 Data collection and analysis

Students were invited to complete the survey immediately after their respective clinical reasoning tutorial and return them to a sealed collection box place placed at Nursing Reception counter. A total of 91 (75.2%) students completed the written survey. Quantitative data (Likert scale and responses for the cues, diagnoses, and actions table for clips 1-3) were collated and entered on an excel spreadsheet by an independent research analyst. Results are reported in simple descriptive statistics. Qualitative data from the open-ended responses were thematically analysed.

3. RESULTS

In this section, RQ 1: 'When performing a nursing assessment for Jerry; a) what cues and information did students identify, and b) what nursing diagnoses, and actions were suggested?' is answered by the presenting summary data for Clips 1 to 3. Results for RQ 2: 'What are the benefits and disadvantages of using holograms to teach clinical reasoning skills?' are presented next along data relating to the student's overall perception of the learning experience.

3.1 Cues, diagnoses, and nursing actions

In the survey, as previously described students were asked to record up to three patient cues, nursing diagnoses and actions for each clip of the scenario in a table on the survey.

3.1.1 Clip 1

The cues identified in clip 1 where Jerry is groaning, restless, is covered in a mottled rash, and has red and inflamed wound
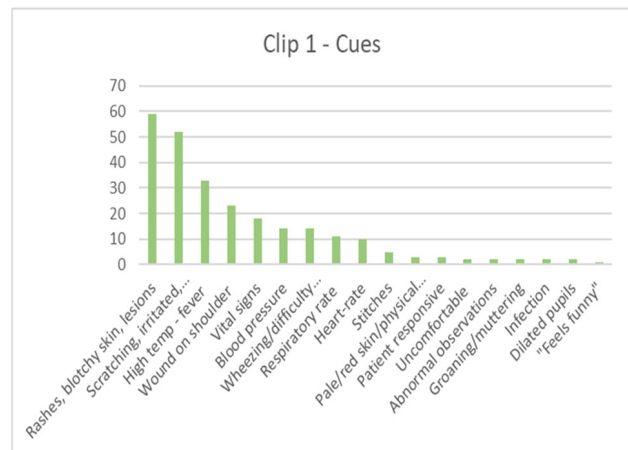
on his back are shown in Figure 3.

Figure 3. Clip 1 Cues

For clip 1, 13 different cues were identified. Reassuringly, nearly two-thirds of students noted details of Jerry's skin appearance, i.e., rashes, blotchiness, and lesions (n = 59), and general demeanour, i.e., scratching, irritated, restless, disorientated (n = 53). Twenty-one nursing diagnoses were suggested but only those with greater than five responses are reported.

Most students thought Jerry was experiencing an allergic reaction or adverse reaction to drugs (n = 68). This was closely followed by the possibility of a septic or infected wound (n = 65), febrile condition (n = 17), rash of unknown origin (n = 12), mental health condition (n = 6) or meningitis (n = 6). Before viewing Clip 2, students were asked to plan nursing care actions for Jerry. Twenty-eight actions were proffered. These ranged from checking health history and medical notes (n = 33), administering antihistamine (n = 21), providing wound care (n = 19), administering antibiotics (n = 18), monitoring vital signs (n = 15) and telling a person in authority (n = 12). Trimming fingernails was included (n = 1) by one thoughtful person obviously concerned about Jerry scratching himself.

3.1.2 Clip 2

The cues students identified in clip 2 where Jerry is febrile, more restless and has elevated respirations, pulse, and blood pressure and increased itchiness and skin redness due to the body's histamine response are shown in Figure 4.

A range of 27 cues were identified, indicating that students had paid attention to Jerry's fast laboured breathing (n = 68), increased restlessness, agitation, and scratching (n = 38), elevated blood pressure (n = 31) and spreading rash (n = 20). Most thought these signs and symptoms were due to an allergic reaction or anaphylactic shock (n = 51), an infected

wound (n = 40) or airway restriction/respiratory issue (n = 17). Other diagnoses ranged from sepsis (n = 8), drug reaction/withdrawal (n = 7), meningitis (n = 5); to leprosy (n = 1) and intoxication (n = 1).
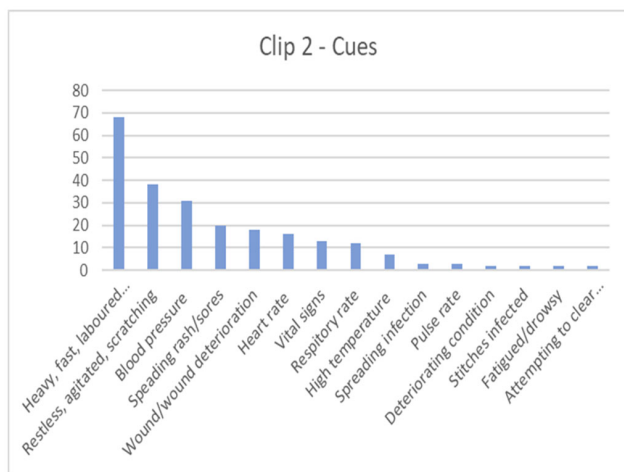

Figure 4. Clip 2 Cues

A total of 41 nursing actions were suggested, including preparing or administering oxygen (n = 39), steroids or adrenaline (n = 24), antibiotics (n = 14). Alerting a person in authority (n = 18), providing breathing coaching (n = 6), talking (n = 4) or staying (n = 3) with the patient, and calling for crash team (n = 3) were also included.

3.1.3 Clip 3
The cues identified in clip 3 where Jerry is slumped in the chair, his speech is slurred, skin flushed, and monitor indicates respiratory depression and shock (blood pressure = 86/60 mmHg, respirations = 9r/min, pulse = 140b/min, temperature = 38.4°C) are shown in Figure 5.

Seventeen cues were identified. Most students observed signs

and symptoms of Jerry's deteriorating condition by recording information such as limp/lethargic/barely conscious/can't support himself (n = 66), blue lips/cyanosis (n = 46), low respiratory rate (n = 42), and high heart rate (n = 21). Twenty-one diagnoses were suggested including anaphylactic shock (n = 42), wound or blood infection (n = 31), increased unconsciousness (n = 17), hypoxia (n = 14) and meningitis (n = 14). The top five nursing actions were to; commence oxygen therapy (n = 51), call an emergency (n = 25), lie him down flat (n = 19), administer adrenaline (n = 18) and get help (n = 12).
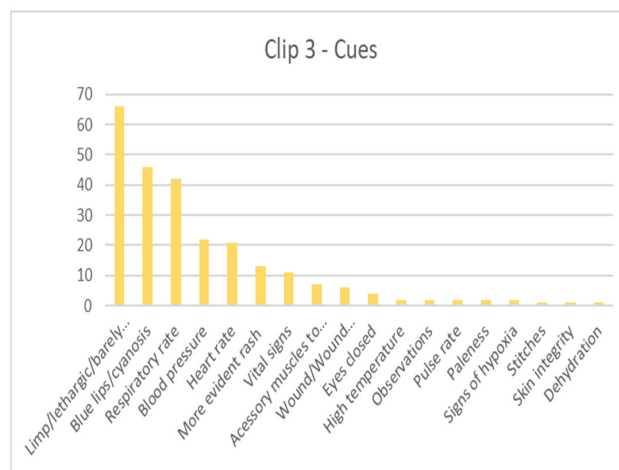

Figure 5. Clip 3 Cues

3.2 Advantages and disadvantages of using holograms
Results relating to RQ 2: 'What are the benefits and disadvantages of using holograms to teach clinical reasoning skills? were thematically anlaysed from the open-ended responses to the survey. Table 1 summarises the main advantages and disadvantages of using holograms (themes with greater than 6 responses are reported).

Table 1. Themes–Advantages and disadvantages of using holograms

Advantages	Disadvantages
Sense of realism (n = 54)	Patient or field of vision was awkwardly positioned for conducting a careful observation (n = 28)
Being able to assess the situation/patient visually (n = 29)	Technical faults (n = 11)
Interactive and applied visual mode of learning (n = 20)	Audio too quiet/lack of verbal responses (n = 10)
Getting to assess a patient and look for cues and a diagnosis (n = 15)	Not being able to assist/interact with the patient (n = 9)
Better prepares you for clinical practice (n = 12)	Poor image quality (n = 7)

A total of 17 advantages were identified from the thematic analysis indicating that students found this style of learning beneficial. Most appreciated were the sense of realism and being able to assess the patient visually. For example,

one respondent noted that *"it was a very realist approach to learning"*, and another that *"it is very life-like with sounds"*. Students also liked the interactive and visual mode of learning and valued the opportunity to assess a patient, look for

cues and make a diagnosis in this tutorial. This is captured by the comment *"it felt like we were really assessing a patient"*.

Qualitative data showed that students appreciated the reality of interacting with the hologram. Many found the experience *"surprisingly real"* and felt that it was easy to be *"fully engrossed in looking at the patient without feeling awkward about it"*. However, the life-like appearance of Jerry caught some off guard. One person felt *"really involved in caring for him"*, and another *"a bit panicky when they saw him deteriorating"*. The benefits of the nurse being anonymous in the scenario were also evident. For example, some said that they *"did not feel self-conscious"* and *"could focus on doing the assessment because they were not being closely watched as they would have been in a normal simulation suite"*. Others appreciated *"the opportunity to assess a patient for real, but not to have to panic about the right questions to ask"*.

Ten students concurred with respondent 77 who thought that *"being able to see first-hand what these symptoms looked like was very helpful"*. Seeing the patient deteriorate over time, *"visualising the symptoms"*, and *"being able to see the patient's situation, rather than reading it off paper"* emphasised the importance of making an assessment visually, particularly in assisting students to manage stressful or rare situations. Many students considered that *"these learning opportunities better prepared them for clinical practice"*. Other positives included that *"it was fun, interactive and educational"*, *"very cool"* and that *"they would love to use it again"*.

Eleven disadvantages, mostly relating to operational issues such as the positioning of the patient and *"the image jumping suddenly or moving"* or the *"field of vision offered by the headset not being expansive enough"*. Low audio volume and poor or *"fuzzy/blurry"* image quality were also mentioned. For some, *"not being able to communicate with the patient"* was a negative feature. Several mentioned discomforts related to wearing the headsets, including that they were: *"a little hard to use and see things"*, *"heavy and kept slipping"*, *"hard to use and see things"* and *"wouldn't stay on without tightening"*. Respondent 15 mentioned that it was *"difficult to process virtual reality in a busy classroom with people moving about"*. However, this situation closely resembled the reality of being in a hospital environment. Several areas for improvement were suggested in the open-ended feedback. These included make it easier to hear the patient, provide a wider field of vison, include the patient medial notes and history, and enable to user to interact with the patients.

3.3 Overall perception of HoloLens® learning experience

Table 2 summarises students' self-rated perceptions of the HoloLens® learning experience. A five-item Likert scale 1 = strongly disagree; 2 = disagree, 3 = neutral; 4 = agree, 5 = strongly agree, was used to rate each statement.

Table 2 shows a high level of satisfaction (M = 4.63) with the learning experience. Students thought that the patient appeared to be very real (M = 4.22) and were confident about assessing the patient from the cues (M = 4.35). However, the result (M = 4.74) for experiencing motion sickness/disorientation from using the headset is concerning but may have been partially due to students swapping headsets whilst they were standing and moving about in the room.

Responses to the two questions about the learning experience as shown in Table 3.

Table 2. Student perceptions of the learning experience (N = 91)

Statement	Mean
It was easy to pick up clues about the condition of the patient	4.48
It was easy to process the information gained from the patient cues	4.43
It was easy to describe the patient situation	4.53
The patient appeared to be very real	4.22
I felt confident about assessing the patient condition from the cues	4.35
It was easy to use the headset	1.72
I felt I needed more support from the teacher when using the technology	1.21
I experienced motion sickness/disorientation from using the headset	4.74
I enjoyed using this technology to learn assessment skills	4.63
I feel that my learning was enhanced by using the HoloLens technology	4.63

Of the 77 who responded to the question: 'Which clip most enhanced your learning in this scenario?' nearly half (47%) of these students found Clip 3 - the anaphylactic shock medical emergency scenario was most effective. This was followed by Clips 1 and 2 (31% and 22%, respectively).

Suggestions for improvement are shown in Table 4.

An interesting range of suggestions for improvement were offered, most of these related to enhancing technological delivery, many of these have been attended to with the introduction of the second-generation headsets and app.

Table 3. Perceived learning enhancement

Which clip most enhanced your learning?	N	%
Clip 1	17	22.08
Clip 2	24	31.17
Clip 3	36	46.75
Overall, was your learning enhanced by this experience?		
Yes	89	97.78
No	2	2.22

Table 4. Suggestions for improvement

	N	%
Make it easier to hear/patient should offer more vocal cues	36	44.44
Improved graphics or visuals	23	28.40
Patient notes and medical history included	19	23.46
A wider field of vision vertically/better positioning of patient for observation	12	14.81
Generate more of a physical environment around the patient	7	8.64
Enable user to assist/interact with patient	7	8.64
02 saturation stats should be visible	4	4.94
A clock to time things or depict how much time is passing	4	4.94
Be informed how to use headset prior - e.g. user can look behind the patient	3	3.70
Ability to zoom in	2	2.47
More realistic behaviours by "patient"	2	2.47
Longer/more clips	2	2.47
Greater comparison of individual answers following the exercise	1	1.23
Have more things go wrong to make it even more interesting	1	1.23

4. DISCUSSION

A major challenge for today's educators is to find ways to engage students in a structured learning environment in the same ways that they engage themselves in their social, personal, and recreational lives.[2] HoloLens® and other MR technologies offer learners the opportunity to interact with life-sized moving and breathing virtual standardised patients, displaying various symptoms and behaviours that can appear more realistic than a high-fidelity mannikin.[3, 16] From a teacher's perspective, using this equipment is straight forward. However, having technical support and training is essential as the headsets may need to be charged regularly, and calibrated throughout the lesson.

Digital competency is essential for all nurses and educators need to prepare students for the digital world in which they will work.[20] These findings show that HoloLens® technology offered an immersive and engrossing learning activity for these students. Comments such as *"it was good to witness the deterioration of the patient without having to rush around"* suggested that this experience helped to develop confidence in nursing assessment skills. As has been found by others[11, 14, 21] this form of simulated learning increased engagement, enjoyment, interest, and group interaction. Furthermore, the anaphylactic shock scenario involved students in a clinical situation that they may not normally see or be allowed to participate in with actual patients thereby developing knowledge about how to recognise and manage a medical emergency, a central tenant of simulation pedagogy.[15]

This study's results support the findings of others[4, 13, 14] suggesting that MR and immersive technologies may fast-track learning, decrease practice time and improve learning outcomes for healthcare students.

For all three clips of Jerry's anaphylactic shock nursing scenario, the students' observations, diagnoses, and nursing actions were appropriate and professional, given they had little clinical experience and had not been fully briefed about Jerry's condition. The breadth of thinking can be seen in the following summary of results.

- Clip 1 – 13 cues, 21 diagnoses, 28 actions
- Clip 2 – 27 cues, 18 diagnoses, 41 actions
- Clip 3 – 17 cues, 21 diagnoses, 25 actions

In Clip 1, most correctly recognised the rashes, blotchiness and lesions and general demeanour, i.e., scratching, irritated, restless, disorientation, and thought that Jerry was experiencing an allergic reaction or adverse reaction to drugs. By Clip 3, Jerry's decreased level of consciousness and critically low respiratory rate were noted leading to a diagnosis of anaphylactic shock to be treated by commencing oxygen therapy

and calling an emergency. The final clip provided these first-year learners with a holographic picture of a high-stakes emergency that they may seldom encounter. Involvement in this realistic learning experience provides students with confidence in nursing assessment and management of a person experiencing anaphylaxis in the future.

4.1 Developing clinical reasoning skills

Developing reasoning skills requires active engagement, practice and reflection that begins in the classroom or simulation laboratory and continues throughout a nurse's clinical practice. Registered Nurses (RNs) engage in multiple clinical reasoning episodes for each person in their care, many times a day. Because of their knowledge, skill and experience, RNs may appear to perform these processes in a way that seems automatic or instinctive. However, students need time to learn how cues shape clinical decisions and recognise the connections between cues and patient outcomes.

These findings indicate that spending time carefully observing, and processing information provided a valuable learning experience that was not easily forgotten. Students valued the opportunity to observe the patient and collect information in a supported learning environment. The following comment: *"I now know the importance of the Early Warning Score, especially what to do when the respiratory rate goes below ten"* is an example of synthesis between theory and practice. Many also indicated that *"participating in this scenario increased my readiness for the clinical setting"*, an important educational outcome for nurses entering today's complex and demanding healthcare environment.[1] Overall, the consensus about the learning experience was that it was *"a modern way of learning when you can't have face-to-face practice"*.

Using the clinical reasoning cycle also encouraged learners to think critically about their observations and information processing. The inclusion of diagnoses such as meningitis, intoxication or mental health conditions provided a valuable teaching and learning opportunity to discuss these conditions and diagnostic criteria, rather than simply to eliminate them. The message given to students in the follow-up tutorial, was not to limit their thinking, rather to have the confidence and courage to record things not seen or noted by others. Interestingly, although some were dissatisfied about not being fully briefed about Jerry's condition in the beginning, most appreciated that this was a different way of learning and that *"not being told made us think harder and be more observant"*.

4.2 Study limitations

The study had two major limitations. Firstly, no personal or demographic data were collected. However, of the 121

students enrolled in this course the majority (N = 109; 90%) were female (N = 112; 93%) and aged between 18-25 years.

Secondly, students were not briefed about Jerry's condition, as the researchers considered that this may have restricted their data gathering or biased their observational and thinking processes. It is acknowledged that may have negatively affected their learning as information about Jerry was withheld. However, this was remedied in a post-tutorial debrief session, and by posting the full information about the scenario into Moodle the course Learning Management System.

4.3 Future directions

This study used the first generation of HoloLens® headset and app loaded onto an instructor laptop computer with a suite of 10 patient scenarios. Since then, Microsoft has released Generation 2 technology which is a more comfortable HoloLens® headset (HoloLens® 2). The company GiGXR has developed the HoloPatient app and now there are several new features and five new patient scenarios, including a person suffering from respiratory distress due to COVID-19. An advantage of the upgraded technology is that students can join a HoloLens® session on a smartphone or tablet, allowing everyone to participate at the same time, rather than taking turns to wear a headset. Another advantage is that learner can also participate from home. The newly developed app allows instructors wearing a Microsoft HoloLens® 2 headset to create and share scenarios (`https://www.gigxr.com/applications/holopatient`). These technologies have the potential for nurses to further develop clinical reasoning skills, through virtual planning and simulation of nursing care.

It should also be noted that the researchers chose not to use the patient scenario briefing notes in this learning activity; the rationale for this was to encourage students to carefully observe, listen and work through the information and cues. This was an effective strategy for first-year students as they pooled knowledge to discuss and explore diagnoses and nursing actions. Furthermore, those who had not observed the wound on Jerry's back learned an important lesson in patient observation and assessment skills – one that they will never forget.

The authors have found using smaller group tutorials (of 4 to 6 students) along the instructor resources and a full debrief for each scenario more effective for second-year students. Finally, having a virtual patient that does not actively communicate with the nurse is a powerful learning tool because it allows individuals time to focus on the person without being too self-conscious and creates an important learning and teaching opportunity about how to communicate with a

non-verbal or non-responsive person.

5. CONCLUSION

Nurse educators work in a technology-rich teaching environment and are expected to use this technology in their teaching and learning experiences. In this study, the clinical reasoning cycle provided a structure that encouraged students to think about their observations and information processing thus developing confidence in assessing patient conditions from visual and aural cues. MR technology and the HoloLens® headset and app introduced students to a real experience of observing a patient, albeit a hologram experiencing anaphylactic shock, a high-risk event that they may infrequently encounter in their clinical practice. Also, rather than being in a classroom or interacting with a manikin in a simulation laboratory or suite, the patient in the room surprises students, thereby enhancing realism that helped students to make a patient assessment visually. Negative aspects related to technical issues, for example that the headsets were hard to use or heavy, that there was an obstructed or blurry view and limited interaction with the patient.

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CONFLICTS OF INTEREST DISCLOSURE

The authors declare that they have no competing interests.

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