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Short Communication

Augmented Reality in Nurse Practitioner Education: Using a Triage Scenario to Pilot Technology Usability and Effectiveness

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Keywords
Augmented reality;
Simulation;
Triage scenario;
Nurse practitioners;
Pilot study

Abstract

Background: Before implementation, simulations and new technologies should be piloted for usability and effectiveness. Simulationists and augmented reality (AR) researchers developed an augmented reality (AR) triage scenario for Nurse Practitioner (NP) students.

Methods: A mixed-method, exploratory, pilot study was carried out with NP students and other volunteers. Participants completed several tools to appraise the usability of the AR modality and the effectiveness of the scenario for learning. Open-ended questions were asked, and qualitative themes were obtained via content analysis.

Results: Mixed results were received by the twelve participants (8 students, 4 other volunteers). There were some issues with usability, and technical challenges occurred. The debriefing was found to be effective, and favorable comments were made on simulation realism. Further preparation for the content and technology, along with more practice, was inferred. Those with reported previous AR experience found the experience more effective.

Conclusions: Further improvements are needed with usability of the AR modality. Debriefing can be effective and the simulation realistic. Participants need further preparation in triaging and use of the technology, and more practice is needed. AR simulations have promise for use in NP education.

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Introduction/Background

Mass casualty incidents impact healthcare systems, resources, and healthcare workers severely. Triage facilitates the optimization of resources and prioritization of care (Lee, 2010). Triage, a systematic approach to evaluate casualties, is the basis of mass casualty incident management (Dittmar, Wolf, Bigalke, Graf, & Birkholz, 2018).

Key Points
- Augmented reality (AR), as a modality, has the potential for use in NP education.
- Simulationists and AR researchers collaborated to develop and pilot test an AR triage management simulation for usability and effectiveness.
- While many aspects of the simulation were found effective, AR usability needs further attention.

Trauma victims are triaged to identify injuries, functional deficits, and the type of patient care (Blackwell, 2020). The type of incident, number of casualties, availability of resources, and severity of injuries play a role in prioritization and disposition of care. Scoring is used in triage to promote consistency in the assessment and to aid in identifying the victim's needs and resources to fulfill such needs (Blackwell, 2020).

Triage protocols for trauma victims, as in mass casualties, must focus on three time-dependent tasks; assessment and recognition of injuries by severity, implementing lifesaving measures, and stabilization and disposition of victims to the proper level of care (Blackwell, 2020). To facilitate the replication of results and improve the quality of triage, triage protocols need standardization (Dittmar et al., 2018). Triage education plays a significant role in achieving this goal, and the need for education with subsequent reinforcement remains relevant to such a purpose (Dittmar et al., 2018).

Augmented reality (AR) use is increasing and has many applications in healthcare education (McCarthy & Uppot, 2019). According to Lioce et al. (2020), AR simulation is defined as one in which information that is generated from a computer appears to be overlaid on actual objects to make the experience better for the user; therefore, it is a mixture of both real and virtual (Madden & Carstensen, 2019).

Wüller, Behrens, Garthaus, Marquard, and Remmers (2019) completed a review of AR research within nursing and located 23 articles. The majority were pilot studies. Differing methods were used to identify cases (scenarios) and to evaluate the AR applications, such as devices, utilized in nursing education. While various AR devices were employed, smart glasses were the most prevalent (Wüller et al., 2019). Only one study was found which used AR in Nurse Practitioner (NP) education (Foronda et al., 2020). In this qualitative descriptive study, telehealth glasses were used to learn endotracheal intubation. Themes from open-ended questions were positively and negatively geared, showing both benefits and challenges (Foronda et al., 2020).

Noted benefits of this innovative technology in prelicensure nursing and NP education include the ability to assist in learning a skill (Aebersold et al., 2018; Foronda et al., 2020; Vaughn et al., 2016), increased confidence (Vaughn et al., 2016), instantaneous feedback (Foronda et al., 2020), interactivity (Aebersold et al., 2018), realism (Vaughn et al., 2016), and feasibility (Aebersold et al., 2018; Wüller et al., 2019). Challenges include technical (Foronda et al., 2020; Wüller et al., 2019), feeling uncomfortable (Foronda et al., 2020), and inexperience with the device (Vaughn et al., 2016). While benefits have been seen in pre-licensure and NP students, only the article by Foronda et al. (2020) specifically mentioned NP students. Therefore, further research on AR for NP students is needed.

Site Background

Although simulation was integrated into Adult-Gerontology Acute Care Nurse Practitioner (AGACNPs) student curricula, neither AR modality nor triage content was included. The perception of the usability of the AR modality and the effectiveness of the triage scenario for learning (Leighton et al., 2018) were unknown. A plan was made at the associated institution to develop, implement, and evaluate a scenario using AR technology. Prior to integration into curricula, a pilot test was planned based on one of the criteria of the International Nursing Association for Clinical Simulation and Learning (INACSL) Standards of Best Practice: Simulation^{SM} Simulation Design (INACSL Standards Committee, 2016). This study is a sub-report of a larger study which also focused on assessing stress and the impact of stress management techniques within an AR triage scenario reported by Stuart et al. (2020). This manuscript is focused on the usability and effectiveness of the AR triage scenario.

Purpose

The purpose of the study was to answer the following questions:

- How did participants feel about the usability of the triage scenario in AR?
- Did participants find the triage simulation effective in AR?

Theoretical Framework

The study was guided by the theoretical frameworks of game-based learning (Plass, Homer, & Kinzer, 2015) and situated cognition theory (Brown, Collins, & Duguid, 1989). Game-based learning theory posits that there are certain foundations in games including: students are challenged with a situation, they receive a response, and then obtain feedback in the debriefing (Plass et al., 2015). In this scenario, each virtual patient was interpreted as a new challenge where the goal was to correctly triage the patient. The response of the player varied with each challenge as they may have had to move around to evaluate physical injuries or gain different amounts of information by asking different questions to the patients. Feedback was given at the end of the simulation.

In situated cognition theory, the importance of the context in which one learns is emphasized, including being authentic (Brown et al., 1989). In this study, an AR platform was chosen to facilitate learning in a realistic, interactive context.

Materials and Methods

Study Design

This was a mixed-method, exploratory, pilot study (Stuart et al., 2020). Several quantitative tools were used. Additionally, open-ended questions were utilized to triangulate the quantitative findings. This was chosen due to the small sample size in an attempt to understand the participant experience with AR.

Simulation Design

The scenario was an AR simulated triage of mass casualty victims chosen as an educational opportunity to scaffold future content in the curriculum. Researchers from two collaborating universities developed the AR simulated triage; one created the scenario with subject matter expert input from the other. Computer graphics models of six virtual patients injured during a bus accident were developed for the scenario (Stuart et al., 2020). An example can be found in Figure 1. The characters were made using Adobe® Fuse CC, and the scripts for verbalization were created using Virtual People Factory 2.0 (Rossen & Lok, 2012). Scripts were created for each virtual patient to allow for the characters to interact with participants verbally (Stuart et al., 2020). A variety of injuries that commonly occur in this type of accident were included (Stuart et al., 2020). The main learner objective was to demonstrate appropriate triage skills during a mass casualty event.

Procedure

Institutional Review Board (IRB) approval was attained. The scheduled simulation-based education (SBE) experience was a course/lab required for AGACNP students; however, participation in the study, e.g., completing study instruments, was voluntary. Students were contacted via email before the SBE experience day about the associated study. Other volunteers with simulation experience were recruited for the study via word of mouth. At the beginning of the SBE experience, the study was presented by protocol personnel with an explanation of research, and consent was obtained for those who wanted to participate in the study portion.

During this SBE experience, participants individually saw six virtual patients using a head-mounted display (HMD); the first patient was for orientation purposes (Stuart et al., 2020). A pre-brief included this tutorial patient to learn the interface tool. Following the orientation/tutorial patient, the participants triaged the first three patients. Participants were then briefly taught stress management techniques individually. These techniques entailed participants asking a few questions as discussed by Hunziker et al. (2013). Afterward, participants triaged the last two patients. They were then individually debriefed (Stuart et al., 2020), with feedback given, on SBE experience objectives, performance (correctness of triaging), and closing of knowledge gaps. The entire SBE experience lasted approximately 20-30 minutes including completion of study instruments. The study instruments reported in this article were collected after the debriefing.

Sample

Eight AGACNP students were recruited to participate with four additional participants; these supplementary participants could include faculty, instructors, adjuncts, and other hourly simulation personnel (hereafter called other volunteers) (Stuart et al., 2020). Additional participants allowed

Figure 1 Example of a patient seen in AR (permission obtained for use of photo).

for evaluation of the SBE experience in an effort to provide feedback for future iterations. There were a total of 12 participants; however, only eleven completed the entire SBE experience through to debriefing.

Instruments

Demographics

Demographics were collected.

System Usability Scale (SUS)

The System Usability Scale by Brooke (1996) is a short, 10-item questionnaire that evaluates usability on a five-point Likert scale ranging from a value of 1 signifying a strong agreement to a value of 5 signifying strong disagreement (Brooke, 1996; Sauro, 2011). The max score is 100 (Brooke, 1996; Sauro, 2011). Converted scores of 68 or less can be interpreted as less than average (Sauro, 2011). It is reliable, valid, and can be used with small sample sizes (Sauro, 2011). The tool was chosen to evaluate the usability of the AR modality in facilitating the participant's ability to triage.

Simulation Effectiveness Tool

Effectiveness of the simulation, in the AR modality, was evaluated with the Simulation Effectiveness Tool - Modified (SET-M) (Leighton, Ravert, Mudra, & Macintosh, 2015). The original SET was created in 2005 and copyrighted by CAE Healthcare (CAE, Healthcare), then it was modified by Leighton et al. (2015). The 19-item tool incorporates a three-point Likert scale ranging from a value of 1 for disagreement to a value of 3 for strong agreement; four subscales are included (Leighton et al., 2015, 2018). A supplementary open-ended question is incorporated for further comments (CAE, Healthcare; Leighton et al., 2018). The Cronbach's alpha for the overall tool was reported as .936, with subscales ranging from .833-.913 (Leighton et al., 2015, 2018). This tool was chosen to evaluate the overall effectiveness of the simulation experience for learning (Leighton et al., 2018) and was determined to be the most appropriate tool available at the time of the study.

Open-ended Questions

The formulation of the qualitative questions was based on the quantitative instruments used in the study; some of these instruments are described in Stuart et al. (2020). Questions were asked related to the usability of a triage scenario and the scenario effectiveness. Participants were able to self-describe their feelings. Allowing participants the ability to formulate their descriptions strengthened the results of the SET-M (Leighton et al., 2015). Open-ended questions were added to explore participant experiences not covered by other tools.

Four open-ended qualitative questions were asked via paper/pencil; two of these were related to effectiveness and usability. The questions focused on two areas: 1) aspects of the virtual patients that helped to learn most effectively and why; and 2) how the medium positively or negatively affected the experience.

Table 1 Demographics

Demographic (N or n Answered)	Number (%)
Gender (N = 12) (Stuart et al., 2020)	
Female	10 (83%)
Male	2 (17%)
Ethnicity/Race (N = 11)	
Caucasian	6 (55%)
Black/African American/Caribbean	2 (18%)
Hispanic/Latino	3 (27%)
Age range	
20-30 years	2 (17%)
31-40 years	5 (41%)
41-50 years	2 (17%)
51-60 years	3 (25%)
Any virtual simulation experiences	
Yes	11 (92%)
No	1 (8%)
Any augmented reality simulation experiences	
Yes	6 (50%)
No	6 (50%)
Any experience triaging patients as a nurse (Stuart et al., 2020)	
Yes	6 (50%)
No	6 (50%)
Any experience triaging patients in mass casualty events	
Yes	3 (25%)
No	9 (75%)

*Numbers rounded in each category to equal 100%.

Analysis

Qualitative data were analyzed via content analysis, a method used to process text and results, resulting in inferences (Krippendorff, 2004). Krippendorff (2004) describes six steps in analyzing data beginning with unitizing the information. Unitizing began with coding a priori words within the data. Data were reduced creating noted themes within the sample set. Inferences were made to connect the data. The inferences were made resulting in a description of unobserved ideas (Krippendorff, 2004).

Quantitative data were analyzed using non parametric descriptive statistics due to assumptions not being met and reported as an aggregate. Chi-square was performed to compare the difference amongst groups reported in demographics. The data were sorted by those who had reported previous virtual and/or previous AR experience.

Results

Demographics

Demographic results are provided in Table 1.

SUS

Ten of the 12 participants completed the SUS (Brooke, 1996). The mean SUS score (Brooke, 1996) was 57. Scores ranged from 0 to 97.5. There was no statistical evidence of a relationship between those who had past AR or virtual experience with SUS scores (p = .69, .80, respectively).

SET-M

Eleven of the 12 participants completed most of the SET-M items (Leighton et al., 2015). Items' means ranged between 1.33 and 2.91. One participant who did not complete the debriefing scores was removed due to missing a whole subscale of the tool; however, all other participants' scores were reported regardless of whether all items were completed (See Table 2).

Open-ended question comments included benefits, such as this was the first-time triaging, and positive comments such as the experience was enjoyable, wanting to participate in more experiences like it, and appreciating the debriefing. Suggestions for improvement were also included (Leighton et al., 2015), such as wanting a full set of vital signs and pulse oximetry from the simulated patient and needing written instructions for triaging. Preparation was a theme along with needing more practice.

The analysis showed no significant difference between those with reported AR or virtual experience and their SET-M scores (p = .329, .727 respectively). Those that had previously reported experience with technology scored higher on the elements of the SET-M.

Qualitative

Components of the open-ended questions facilitated each participant's ability to express their feelings related to the AR experience in their own words. As with the qualitative comments on the SET-M (Leighton et al., 2015), open-ended questions showed positive remarks, such as its use for visual learners, the reality of the experience, how it was a safe environment, and appreciation of the debriefing/feedback following the experience with a discussion of correct triage responses. Realism was a theme that emerged in several participant responses related to the virtual patients presenting as real patients, and seeing the patients and associated injuries helped with learning. Negative comments were made about technical glitches and side effects experienced with the device (See section *Lessons Gleaned – AR Researchers).*

Table 2 SET-M (N = 11) (Leighton et al., 2015)

Item (Number Answered If Less Than 11)	Minimum	Maximum	Mean	Standard Deviation
Prebriefing subscale				
Q1. Confidence	2.00	3.00	2.73	.47
Q2. Beneficial	2.00	3.00	2.64	.50
Learning subscale				
Q3. Preparation	1.00	3.00	2.09	.70
Q4. Understanding (Patho)	1.00	3.00	2.09	.70
Q5. Assessment skills	1.00	3.00	2.36	.67
Q6. Empowered	1.00	3.00	2.55	.69
Q7. Understanding (Medications) – Optional item (n = 3)	1.00	2.00	1.33	.58
Q8. Practice	2.00	3.00	2.82	.40
Confidence subscale				
Q9. Prioritize	2.00	3.00	2.64	.50
Q10. Communicating	1.00	3.00	2.09	.70
Q11. Teach	1.00	3.00	1.64	.81
Q12. Report to team	1.00	3.00	1.91	.83
Q13. Safety (n = 10)	1.00	3.00	2.20	.79
Q14. Evidence-based practice (n = 10)	1.00	3.00	2.20	.79
Debriefing subscale				
Q15. Learning	2.00	3.00	2.73	.47
Q16. Verbalize	2.00	3.00	2.91	.30
Q17. Valuable	2.00	3.00	2.91	.30
Q18. Self-reflect	2.00	3.00	2.91	.30
Q19. Constructive	2.00	3.00	2.91	.30
Overall			44.7	7.71

Q = Question number; numbers rounded.
*Permission obtained to use from Dr. Kim Leighton.

Discussion

Similar to the Foronda et al. (2020) study, positive and negative findings were found. The score on the SUS was less than average (Sauro, 2011) which showed some issues with the usability of the AR modality. Technical errors did occur during simulation implementation, which could have influenced participant perception on usability and simulation effectiveness (*See Lessons Gleaned – AR Researchers*). Improving the usability of AR is a theme in other studies (Foronda et al., 2020).

Several of the items which scored lower on the SET-M (Leighton et al., 2015) were not covered within the scenario. The participants did not engage in teaching patients or reporting to a team and the use of medications was not expected. While preparation was not the lowest, several of the qualitative comments were related to this concept. Preparation for participants appeared vital, both with the technology and with the content. Participants' highest SET-M scores were observed in the debriefing subscale items (Leighton et al., 2015). These results revealed that debriefing allowed them to evaluate the simulation. Since only a small number of the participants had experience triaging, this could have added to why participants scored some of the SET-M (Leighton et al., 2015) items lower. Overall, the participants felt the triage simulation was a useful experience for learning. Since several comments were made about the realism, it appears that the environment made many feel they were in the scenario.

Reported experience with AR influenced the SET-M (Leighton et al., 2015) scores. Participants with prior knowledge and application of AR environments scored higher. This relationship may pertain to the level of ease and comfort with technology, which influenced how participants felt about the simulation's overall effectiveness, while reported virtual experiences did not have the same significant effect.

The SBE experience was beneficial for many of the participants. Lessons were gleaned from the faculty involved and the AR researchers.

Lessons Gleaned – Faculty

It was assumed that most participants would have triage experience as a nurse and learned the basics of triage management; however, demographics and several open-ended comments showed this was not true. Although triaging was reviewed at the start of the simulation, participants reported needing more, such as written instructions.

Lessons Gleaned – AR Researchers

Multiple technical errors occurred during the implementation of the simulation, similar to technical issues reported in other studies (Foronda et al., 2020; Wüller et al., 2019). In this study, these included the inability to connect to Wi-Fi, causing the virtual humans to be unable to communicate back with the participants verbally as planned. As a result, premade scripts for each virtual human were read aloud to the corresponding responses for participants' questions and statements. It was discovered that it is imperative with this type of technology that a technician be available for troubleshooting. Although not anticipated and unusual per some of the authors' experience, several participants experienced dizziness with the use of the HMD. Immersion sickness is a possible side effect of virtual and AR applications per Bryne (2017) as cited in Wüller et al. (2019).

Limitations

Limitations included the small sample size and a mixture of AGACNP students and other volunteer participants. While all students had to participate in the simulation, completing the study's tools was voluntary. Students participating in the simulation at the end of the day may have felt rushed and/or tired and therefore, chose not to complete all instruments. Some items were skipped by participants on the SET-M (Leighton et al., 2015). Additionally, the SET-M (Leighton et al., 2015) is not explicitly designed to evaluate AR simulations; a newer adapted version of the SET-M (one item modified) may be more appropriate (Leighton et al., 2018). Multiple technical errors occurred.

Conclusions

AR may play a useful role in NP education; however, the usability of the AR modality still needs further improvements. Participants felt the usability could be improved. Technical glitches can occur during the AR SBE, and backup plans for such occurrences are essential, as is the presence of someone with technical expertise. Participants may need to be informed of possible adverse effects with the use of HMDs. However, AR simulations can be effective, especially when accompanied by debriefing, and they can also be perceived as realistic. Participant experience with the task of triaging was challenging for many participants.

Further preparation of participants may need to occur both with content (triage) and with the technology. There is a need in the current medical climate for AGACNP students to be educated on and have training with triaging patients. Having experience with AR may influence participant perception of effectiveness. Further research for AR use in nursing, particularly with NP students, is needed, and outcomes of use need exploration.

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Conflict of Interest

Mindi Anderson - Multiple grants; VP of Operations (INACSL) and *Clinical Simulation in Nursing* Reviewer; Associate Editor *Simulation & Gaming*; Editorial Board *Simulation in Healthcare*.

Benjamin Lok – Multiple grants. Per Dr. Lok, Shadow Health, Inc. is no longer a conflict.

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