Clinical Simulation in Nursing (2022) 69, 40-48

Clinical Simulation in Nursing

www.elsevier.com/locate/ecsn

Augmented Reality (AR) as a Prebrief for Acute Care Simulation

Mindi Anderson, PhD, APRN, CPNP-PC, CNE, CHSE-A, ANEF, FSSH, FAAN[a,*], Frank Guido-Sanz, PhD, APRN, ANP-BC, AGACNP-BC[a], Steve Talbert, PhD, RN[a], Christopher W. Blackwell, PhD, APRN, ANP-BC, AGACNP-BC, CNE, FAANP, FAAN[a], Marci Dial, DNP, MSN, PMGT-BC, CHSE, LNC; PhD student[a], Ryan P. McMahan, PhD[b], Desiree A. Díaz, PhD, FNP-BC, CNE, CHSE-A, ANEF, FAAN[a]

[a] *University of Central Florida (UCF) College of Nursing, Orlando, FL 32826, USA*
[b] *UCF Department of Computer Science, Orlando, FL 32816, USA*

KEYWORDS
augmented reality;
nurse practitioners;
orientation;
pre-simulation preparation;
prebrief;
simulation

Abstract
Background: There is sparse literature describing Augmented Reality (AR) usage as pre-simulation preparation (i.e., prebrief) prior to other types, such as manikin-based, and how participants are oriented to AR.
Methods: A multi-method study was piloted with adult-gerontology acute care nurse practitioner (AGACNP) learners. Participants were oriented to the AR headset and participated in an AR experience during prebrief followed by a high-technology, manikin-based simulation. Usability, effectiveness, and participant side effect data were gathered via surveys and qualitative questions. Four open-ended questions were answered, and anecdotal notes were taken.
Results: The AR prebrief activity, in total, averaged about 21 minutes or less. Side effects that occurred during the experience mainly were oculomotor. Usability was less than average; however, during the prebrief phase, the AR activity appeared to be effective in the overall simulation experience per an effectiveness tool.
Conclusions: AR can be utilized during prebrief. There are multiple faculty considerations. Further study for AR during prebrief is needed.

Cite this article:
Anderson, M., Guido-Sanz, F., Talbert, S., Blackwell, C.W., & Díaz, D.A. (2022, Month). Augmented Reality (AR) as a Prebrief for Acute Care Simulation. *Clinical Simulation in Nursing*, 69, 40-48. https://doi.org/10.1016/j.ecns.2022.05.005.

Augmented Reality (AR) as a Prebrief for Acute Care Simulation

The literature substantiates the use of simulation-based teaching strategies in nursing education (Bye, 2014;

* Corresponding author. mindi.anderson@ucf.edu (M. Anderson).

https://doi.org/10.1016/j.ecns.2022.05.005

Nye, Campbell, Hebert, Short, & Thomas, 2019; Tyerman, Luctkar-Flude, Graham, Coffey, & Olsen-Lynch, 2019). The Healthcare Simulation Standards of Best Practice™ (HSSOBP™) Simulation Design calls for attention to the planning and development throughout each phase of simulation-based activities (INACSL Standards Committee, Watts, et al., 2021). A criterion of simulation design (number eight), that is prebriefing, focuses on the essential aspects of preparation and structuring of pre-simulation activities to facilitate participant success (Díaz & Anderson, 2021; INACSL Standards Committee, Watts, et al., 2021). This criterion of design (INACSL Standards Committee, Watts, et al., 2021) is further articulated in the HSSOBP™ Prebriefing: Preparation and Briefing (INACSL Standards Committee, McDermott, Ludlow, Horsley, & Meakim, 2021). Prebrief is a significant contributor to any simulation-based education (SBE) activity. It serves as the foundation for a successful trajectory toward meeting intended outcomes (Chmil, 2016; Díaz & Anderson, 2021; INACSL Standards Committee, McDermott, et al., 2021; McDermott, 2016). Therefore, when designing SBEs, it is essential that planning follows evidence-based guidelines and that all aspects of the simulation are addressed, including the prebrief (Chmil, 2016; Nye et al., 2019).

Key Points

- Prebriefing is foundational for successfully meeting established simulation outcomes.
- Integrating AR technology into the prebrief phase may enhance simulation experiences.
- Further research is needed in AR for prebrief learning.

Preparation for simulation is suggested (Der Sahakian et al., 2015; INACSL Standards Committee, McDermott, et al., 2021; Tyerman, Luctkar-Flude, Graham, Coffey, & Olsen-Lynch, 2016) and is included in three specific criteria within the HSSOBP™ Prebriefing: Preparation and Briefing (INACSL Standards Committee, McDermott, et al., 2021). Participants should recognize the constructs they will encounter during SBE activities (INACSL Standards Committee, McDermott, et al., 2021). Evidence-based literature from articles and/or course materials may be provided as simulation prework (Fraser, Ayres, & Sweller, 2015; INACSL Standards Committee, McDermott, et al., 2021; Leigh & Steuben, 2018; Tyerman et al., 2016). Other pre-simulation preparation activities include quizzes or other types of evaluation (INACSL Standards Committee, McDermott, et al., 2021; Leigh & Steuben, 2018; Tyerman et al., 2016) that can help identify knowledge gaps (Tyerman et al., 2016). These activities can include lectures, case studies, concept maps, or virtual simulations, among others (Bye, 2014; INACSL Standards Committee, McDermott, et al., 2021). Orientation modules, concept mapping, and/or other assignments can also be completed before the simulation (INACSL Standards Committee, McDermott, et al., 2021; Leigh & Steuben, 2018).

Nursing simulation educators create learning environments conducive to engaging learners in experiences that allow them to perform actions as they would in an actual situation (Leighton, 2018). In addition, immersive learning environments may integrate technologies. Examples of these modalities include the use of virtual reality (VR), augmented reality (AR), or mixed reality (Foronda et al., 2017; Leighton, 2018). Interest in the application of using AR within healthcare academic programs is growing (McCarthy & Uppot, 2019; Mendez et al., 2020).

Emerging AR modalities utilizing see-through head-mounted displays (HMDs), augment the user's perspective of the real-world environment with virtual objects or data visualized with computer graphics (LaViola, Kruijff, McMahan, Bowman, & Poupyrev, 2017). This type of technology creates a coexistence between three-dimensional virtual entities and the real world (Zhu, Hadadgar, Masiello, & Zary, 2014), whereas VR immerses the user in a completely virtual world (Bowman & McMahan, 2007) and is highly realistic (Shin, Rim, Kim, Park & Shon, 2019). Unfortunately, definitions, especially of VR, are confusing and not standardized (Kardong-Edgren, Farra, Alinier, & Young, 2019).

Madden and Carstensen (2019) discuss the addition of an AR HMD with holographic scenarios into nursing curricula and the potential for closer alignment of the academic-practice gap. Authors indicate the future of AR technology is promising in SBE (Aebersold & Schneidereith, 2020; Vaughn, Lister, & Shaw, 2016). Aebersold and Dunbar (2020) also emphasize that contemporary nurse educators use these innovative modalities.

AR/VR technologies offer immersive experiences that reach beyond traditional methods making learning engaging, with the potential to lower the time needed to practice and bolster learning outcomes (Foronda et al., 2017; Mendez et al., 2020). However, before adding these technologies, educators should conduct pilot sessions to assess their usability and effectiveness (Anderson et al., 2021). Using a pilot test before full implementation also allows the simulation designers to evaluate the structure of pre-simulation activities, including the structure of the prebrief component of the activities, especially when participants will be working with unfamiliar equipment or procedures (Leigh & Steuben, 2018).

Additional areas for exploration include clinical decision-making, skill acquisition, looking at the practicality of using headsets/controllers, and the ability to gain insight into the participant's comfort level using the technology related to the success of the simulation experience (Aebersold et al., 2018; Aebersold & Dunbar, 2020; Foronda et al., 2020; Mendez et al., 2020; Vaughn et al., 2016; Wüller, Behrens, Garthaus, Marquard, & Remmers, 2019). Furthermore, integrating AR and VR technologies into SBE activities involves structured faculty development programs and institutional support (Mendez et al., 2020). As the recognition of the value and importance of prebriefing and its impact on the simulation experience and learning grows among scholars, available nursing undergraduate and graduate-level education information continue to develop (Tyerman et al., 2016). However, limited literature is available discussing the use of AR during the prebrief phase.

Orientation to the AR device is also sparse in nursing. Authors have described orientation to the AR device, application, and/or simulation, including verbal instructions, demonstration (Aebersold et al., 2018), a tutorial patient (Anderson et al., 2021), or even a prebriefing (Vaughn et al., 2016). However, others have not described orientation processes (Foronda et al., 2020; Kotcherlakota, Pelish, Hoffman, Kupzyk, & Rejda, 2020). Although AR simulation is valuable as a teaching strategy for NP educational content (Kotcherlakota et al., 2020), much is unknown about how learners perceive the usability and effectiveness of AR scenarios, especially adult-gerontology acute care nurse practitioner (AGACNP) learners (Anderson et al., 2021). A prior pilot study of an AR triage scenario as the SBE with AGACNP learner participants discovered usability and technical errors. In addition, side effects of AR were noted. Therefore, further data must be collected in these areas (Anderson et al., 2021).

Need at Site

The associated university received a grant to purchase Microsoft HoloLens 2 HMDs (Microsoft, 2019) and prepackaged acute care scenarios (CAE Healthcare, n.d.). Acute care scenarios were utilized as AGACNPs must be trained to manage acute, critical, and chronic patients using data (The National Organization of Nurse Practitioner Faculties & American Association of Colleges of Nursing, 2016). Learners previously had completed a manikin-based, high-fidelity simulation immersive scenario on myocardial infarction (MI). Therefore, the faculty deemed that the use of AR might enhance curricular content with additional experiential learning. In addition, the faculty felt this approach might improve knowledge of MI beyond reading alone as pre-simulation activity (hence after called prebrief). To date, no one method of prebriefing is more successful than another (Tyerman et al., 2016); it should be based on a multitude of factors including the objectives of the simulation (McDermott, 2016). However, authors have suggested that such activities be engaging (Leigh & Steuben, 2018; McDermott, 2016). Since little is known about orientation to the AR device and incorporation into prebriefing, this pilot study explored integrating an AR activity during the prebrief phase, using HMDs with AGACNP learners with a cardiac-related MI scenario.

Purpose

The purpose was to explore the following:

- Amount of time for participants to complete the AR orientation and AR prebrief scenario, that is, activity.
- Usability and effectiveness of the AR activity during the prebrief phase.
- Experienced side effects from the AR activity during the prebrief phase.
- Effectiveness of the high-technology, manikin-based simulation following the AR prebrief activity.

Operational Definitions

Augmented Reality (AR) includes computer-generated information or overlays projected into reality (Lioce et al., 2020). In addition, the prebrief includes pre-simulation activities, defined as the time preceding the simulation, which may also occur on the day of (Díaz & Anderson, 2021; INACSL Standards Committee, McDermott, et al., 2021; INACSL Standards Committee, Watts, et al., 2021). Finally, recognizing that fidelity goes beyond the modality (i.e., such as a manikin), a high-technology simulator refers to a manikin with high complexity (Carey & Rossler, 2021; Weintraub et al., 2017) that is realistic.

Theoretical Framework

Mezirow's (2000) Transformational Learning Theory was the underpinning framework for this part of the study. This theory has been linked to prebriefing (Briese, Evanson, & Hanson, 2020), particularly during the first of the 10 Transformational Learning Theory phases outlined by Mezirow (2000). In this phase, known as "a disorienting dilemma" (Briese et al., 2000 , p. 64, 65, 67; Mezirow, 2000, p. 22), a problem the participant must solve occurs (Briese et al., 2000). The idea of problem-solving for the learner to reconstruct knowledge, facilitated by faculty, is the foundation of the AR prebrief activity.

Methods

After the Institutional Review Board approved the study as exempt, learners were recruited via email before the simulation day to participate in this mixed-methods pilot study. On the day of the simulation, the opportunity to volunteer as a participant in the study was presented to possible participants again by noncourse study personnel. The orientation and prebrief, including the AR activity, occurred as part of the scheduled simulation laboratory. Learners could choose if they wanted to be part of the study (Guido-Sanz et al., 2022a,b).

Participants

Participants ($N = 12$) included AGACNP learners who were a part of a previous larger study evaluating simulation within the program and included evaluation of the effectiveness of all simulations during the day ((Guido-Sanz et al., 2022a,b). This was the entire cohort (100%) of those in the course. In this part of the study, non-learner volunteers also participated. Due to their limited number ($N = 3$) and not participating in the follow-up high-technology, manikin-based simulation, their data were not reported. However, anecdotal notes discussed are based on lessons learned from the entire group.

Orientation and Simulation

Orientation/Prebrief (AR Prebrief Activity)

Participants completed the orientation to the AR headset and then the AR activity. The orientation was done via the tutorial app within the head-mounted display (HMD), that is, HoloLens Tips (Microsoft, 2019). Participants self-determined when they believed they completed the orientation. Following orientation, during the prebrief phase, all participants partook in the myocardial infarction (MI) activity using the AR headset (AresAR; CAE Healthcare, n.d.). This activity was conducted with the device only, that is, hologram patient; there was no associated manikin. Following the AR MI activity, learners proceeded to a separate high-technology, manikin-based simulation without an HMD based on MI content, but it was a different scenario.

High-technology, Manikin-based Simulation Following Prebrief Phase

Two AGACNP faculty content experts developed a scenario following the American Heart Association (2020) Advanced Cardiovascular Life Support (ACLS) Ventricular Fibrillation (V-Fib) Algorithm. Learners completed the simulation of a symptomatic patient developing an acute ST-segment elevation MI. They were separated into four sets of three learners, with one learner acting as team leader.

A high-technology simulator (Gaumard® HAL® S3201; Gaumard® Scientific, n.d.) was used for the simulation. The participants were expected to assess, diagnose, plan, and intervene appropriately as the simulation evolved. The patient developed V-Fib cardiac arrest, and ACLS protocol for V-Fib (American Heart Association, 2020) was simulated. The endpoint was the return of spontaneous circulation following the implementation of the ACLS protocol (American Heart Association, 2020). Learners were debriefed after the activity.

Debriefing of AGACNP Learners

As per usual lab activities, a faculty facilitator conducted the group debriefing and used a modified Plus-Delta approach (Cheng et al., 2021) with Socratic questions (Dinkins & Cangelosi, 2019) related to the objectives, learner performance, and any gaps (Anderson et al., 2021). Participants reflected on their assessment and diagnostic reasoning skills, teamwork, and communication competency. Finally, participants appraised the simulation, providing positive feedback and identifying barriers and areas needing adjustment within the scenario and in their professional growth.

Instruments

Demographics

Demographics included role, gender, ethnicity/race, age range, yes/no experience with AR, comfort with AR/VR, and whether they were "gamers."; some of these were previously described in Guido-Sanz et al., (2022a,b) as an additional part of the overall study.Participants also reported whether they had prior MI patient care experience.

System Usability Scale (SUS)

The System Usability Scale (SUS) tool is a concise, 10-item, Likert-scale questionnaire regarding the usability of the equipment/scenario (Brooke, 1996). The instrument was administered following the debrief of the content for the AR prebrief activity in the evaluation of the usability of the AR activity during prebriefing. Each item was rated on given points (1-5), from strong disagreement to strong agreement, respectively (Brooke, 1996). As with previous AR studies (Anderson et al., 2021), the directions were followed to convert the scores out of 100 and then interpret them based on published suggestions (U.S. General Services Administration, Technology Transformation Services, n.d.). A target score of at least 68 is desired (U.S. General Services Administration, Technology Transformation Services, n.d.).

Virtual Reality Sickness Questionnaire (VRSQ)

The Virtual Reality Sickness Questionnaire (VRSQ) tool evaluates cybersickness (Kim, Park, Choi, & Choe, 2018). The VRSQ has two subscales composed of nine Likert-type items asking respondents to identify the degree to which they experienced physical symptoms associated with (motion) cybersickness. The Oculomotor subscale is composed of the first four items. The Disorientation subscale is composed of the last five items. All items are scored zero to three. The subscales scores are calculated as percentages, with the VRSQ scored as an average of the two subscales (Kim et al., 2018). Permission for use was obtained. This instrument was administered after the debriefing for the content of the AR prebrief activity and used to answer whether participants experienced side effects from AR.

Open-Ended Questions

Participants received four open-ended questions to answer after the debriefing for the content of the AR prebrief activity. These questions assessed how much pre-simulation training was desired, the amount of time given to learning, beliefs on what could facilitate learning with the technology, and additional comments.

Time

The time it took for participants to complete the AR prebrief activity was recorded in seconds, including the time to complete the orientation to the device. Time in seconds was converted to minutes for analysis. This conversion showed the amount of time required by participants to finish both the orientation and AR scenario.

Simulation Effectiveness Tool–Modified (SET-M)

This tool by Leighton, Ravert, Mudra, and Macintosh, (2015), modified from the SET by METI (now CAE Healthcare) (Leighton et al., 2015, Leighton, Ravert, Mudra, & Macintosh, 2018), was used as an assessment for the efficacy of the AR prebrief activity in the follow-up manikin-based simulation. Each question on the 19-item, four subscale tool was evaluated from complete lack of agreement to strong agreement (Likert 1-3) (Leighton et al., 2015, 2018). One final question, which was open-ended, was provided for other remarks (Leighton et al., 2015). Previous reliability on the instrument is reported as high, with subscales from 0.833 or greater (Leighton et al., 2015, 2018). Permission was obtained for use (Guido-Sanz et al., 2022a,b), and this was collected after the debriefing.

Data Analyses

Descriptive statistics were reported for learner demographics. Findings for the SUS (Brooke, 1996), VRSQ (Kim et al., 2018), and SET-M (Leighton et al., 2015) were summarized using mean (M), standard deviation (SD), minimum, and maximum values. Total and subscale scores were calculated for the VRSQ (Kim et al., 2018) and SET-M (Leighton et al., 2015). Content analyses for the qualitative data were attempted using (Krippendorff's, 2004) six-step approach, including "unitizing, sampling, coding, reducing, inferring, and narrating" (p. 83).

Table 1 Student Demographics (N = 12).

Gender	
Female	11 (91.7%)
Male	1 (8.3%)
Race/Ethnicity	
Caucasian	9 (75.0%)
Hispanic/Latino	1 (8.3%)
Asian	1 (8.3%)
Multiracial	1 (8.3%)
Age (In Ranges)	
20-30	4 (33.3%)
31-40	7 (58.3%)
51-60	1 (8.3%)
AR Simulation Experience	
Yes	2 (16.7%)
No	10 (83.3%)
Comfortable with AR/VR Tech	
Yes	8 (66.7%)
No	4 (33.3%)
Gamer	
Yes	1 (8.3%)
No	11 (91.7%)
Prior MI Experience	
Yes	11 (91.7%)
No	1 (8.3%)

Cumulative % may not = 100% due to rounding. Some reported in Guido-Sanz et al. (2022a,b).

Results

Demographics

Twelve learners completed the study (Guido-Sanz et al., 2022a,b). Over 90% were female (n = 11; 91.7%). The majority (n = 9; 75%) were Caucasian with 58.3% (n = 7) of the participants being between the ages of 31 and 40 (Guido-Sanz et al., 2022a,b). Most did not have experience with AR (n = 10; 83.3%), and most were nongamers (n = 11; 91.7%). See Table 1 for further demographics.

Usability

The usability of the AR activity was calculated (Brooke, 1996). For learners, the mean was 58.96, with a standard deviation (SD) of 21.88. The minimum score was 22.50, while the maximum was 97.50. One participant had almost all "Strongly disagree" on each item (Brooke, 1996).

Side Effects

The Oculomotor score was a mean of 18.06 with an SD of 21.27 (Kim et al., 2018). The minimum score was 0.00, while the maximum was 75.00. The Disorientation score was a mean of 9.44 with an SD of 14.62. The minimum

Table 2 Simulation Effectiveness (Leighton et al., 2015).

Subscale	*Mean*	*SD*	*Minimum*	*Maximum*
Prebriefing	3.00	0.00	3.00	3.00
Learning	2.93	0.26	2.00	3.00
Confidence	2.99	0.11	2.00	3.00
Debriefing	3.00	0.00	3.00	3.00
Total	*56.45*	*1.81*	*51*	*57*

score was 0.00, while the maximum was 46.67. The total score was a mean of 13.75, with an SD of 16.21. The minimum score was 0.00, while the maximum was 47.50 (Kim et al., 2018).

Open-ended Questions

Eleven participants answered one or more than one open-ended questions. However, the written responses lacked depth and varied in reflection. Nevertheless, the information was used to corroborate and support the findings of the study aims.

On how much pre-simulation training is needed, about 50% of participants believed that less than or equal to 30 minutes is sufficient for orientation. Approximately 31% of the statements reflected that increased time for orientation was needed. There were three themes for describing the amount of time given for the experience versus learning needs: specific to the person, time, and technology.

What could be added to facilitate learning also resulted in three themes. About 63% of participants referred to fixing technology-related issues. Others wanted decreased noise as well as increased practice. Finally, on other comments about the activity, the responses focused on the environment and education. Themes included technical issues, medical considerations, and innovative applications. Innovative applications comments were generally positive.

Time

The mean time for orientation of the nine participants that completed this portion of the AR prebrief activity was 5.51 minutes with an SD of 1.26 minutes. The minimum was three minutes, and the maximum was 6.92 minutes. Three participants had a zero (0) value for the orientation time and were excluded from the analysis. The mean simulation time (i.e., AR MI prebrief scenario) for $N = 12$ was 15.41 minutes with an SD of 4.78 minutes. The minimum was eight minutes, and the maximum was 22.53 minutes.

Simulation Effectiveness

The SET-M subscales and total (Leighton et al., 2015) are provided in Table 2. The prebrief portion had a mean of 3.00 with an SD of 0.00.

Anecdotal Notes

Anecdotal notes revealed that participants needed many verbal directions. This need occurred with selecting, touching, "air-tapping" (menus) (Madden and Carstensen, 2019, p. 28), fixing items to the floor, and/or positioning. For example, facilitators needed to use phrases, such as "peck like a chicken" or "like you are poking someone," especially with selecting and "air tapping" (Madden and Carstensen, 2019, p. 28) on menus. In addition, facilitators had to remind participants how to touch with their fingertips.

Fixing items to the floor and positioning the bed or patient was often a challenging task, and sometimes, items floated out of the display view. When things went wrong, such as objects following them or not being able to put back patient organs, facilitators had to walk the participant through the process while simultaneously not being able to "see what the participant saw." Troubleshooting often resulted in restarting the scenario. This may have been a result of lack of learner and faculty comfort and experience with the technology.

Discussion

The SUS (Brooke, 1996) score was less than average (U.S. General Services Administration, Technology Transformation Services, n.d.). The target goal of a score of 68 was not met; however, the score was greater than in a previous AR study that included similar learners (Anderson et al., 2021). The overall sample was small and from a single institution; future inquiries should encompass larger samples derived from multiple institutions.

Several learners experienced side effects (Kim et al., 2018), also found in a previous AR study (Anderson et al., 2021). It is difficult to interpret the VRSQ scores (Kim et al., 2018) as score interpretation is still being examined (J. Park, personal communication, August 14, 2021). However, more learners had oculomotor side effects such as discomfort and eye issues, including strain, among others (Kim et al., 2018).

In addition, some learners experienced disorientation side effects, such as headache or dizziness (Kim et al., 2018). These effects may have been exacerbated if learners skipped the calibration step during the device orientation. Additionally, some learners were frustrated with multiple attempts at the orientation, so three learners opted not to join in this part of the exercise. For future use, learners should complete the tutorial/orientation until the device is calibrated. About 21 minutes or less were needed to complete the orientation and activity for those who completed the orientation. While about half of the learners believed 30 minutes was adequate for the AR activity, a little over 30% (estimated) wanted more time.

Overall, the simulation effectiveness, following the AR activity during the prebrief phase, was perceived as beneficial by the learners (Leighton et al., 2015). The prebrief portion of the SET-M on the follow-up manikin-based simulation was rated high showing that the AR prebrief was effective. The faculty believed this activity was helpful for anatomy and physiology review prior to the manikin-based simulation. This has been proposed as an excellent teaching strategy for such concepts (Foronda et al., 2017).

Faculty Considerations

Faculty considerations for the AR prebrief activity, based on the anecdotal notes and experience, include:

- Multiple faculty are needed. In this study, several research faculty were essential to facilitate (two-three), especially for the first learner experience. However, this may be able to be decreased in the future once comfort is obtained.
- Directions and instructions are necessary. Specific written instructions were required on how to access the applications, complete the orientation, and the AR prebrief activity itself. Providing a tip sheet for facilitators and learners may be beneficial.
- The importance of completing eye calibration should be emphasized. Orientation should be completed at least through this step.
- Tips for use include having ample space and a semi-darkened room. It is essential to remove tripping hazards. Distractions, such as noise, need to be mitigated.
- Time is needed for orientation to the device, such as the HMD, and the actual AR prebrief activity. Findings from this study support increasing the allotted time to one hour if permissible, at least for the first exposure. Again, once oriented, this may be able to be decreased. If possible, time should be built in for repeating the AR prebrief activity. Some of the participants' open-ended responses verified this.
- A faculty or other member is needed to clean the headsets between participants. CleanBox (n.d.) uses ultraviolet light to sanitize (Hedrick, 2020) and was utilized in this study. This measure was imperative, especially during the COVID-19 pandemic.
- Syllabi language should be written that if headache, dizziness, or other side effects occur, the user should take off the AR headset and stop the simulation. Faculty should consider alternatives ahead of time for those who cannot complete the AR prebrief activity to meet the same objectives. A backup plan, such as suggested by Dang et al. (2021), is needed. The simulationist or faculty member should determine the backup plan, remembering that the learner must reach the same objectives. For example, outside of a prebrief, this could be a manikin-based simulation. During the prebrief phase, possibly a virtual simulation or other strategies via a computer screen (Dang et al., 2021).
- Integration of this technology should be scaffolded and piloted.

Limitations

The AR prebrief activity was done only with the device, that is, a holographic patient with no manikin. Results might have been different if a manikin was involved. Additionally, not all learners completed the orientation. Written responses to open-ended questions potentially lacked capturing complete sentiments due to limited depth of reflection. Finally, the SET-M (Leighton et al., 2015) would be changed to include the adapted question for virtual simulations (Leighton et al., 2018) if using with AR alone as the activity. Although this was augmented reality and not a virtual simulation, this action was suggested in previous AR studies (Anderson et al., 2021).

It is unclear when participants completed the SET-M during the sequenced simulations, for example, after the AR prebrief experience or after the manikin-based session. It could be beneficial to ensure the time of completion in the future. Learners may not have equated pre-simulation activities to the term prebrief.

More research is needed in AR, especially during the prebrief phase, as this was only a pilot. Looking at learner engagement (Der Sahakian et al., 2015; Leigh & Steuben, 2018; McDermott, 2016) with and without the use of AR during the prebrief is one area that may be studied. Comparing different prebriefing methods may also be helpful, for example, AR versus a more traditional method (such as reading) (Tyerman et al., 2019), as there may be some limitations with AR use. This can include cost, number of learners able to be prebriefed at a time, and others. For example, outcomes may include confidence (McDermott, 2016). In addition, AR's side effects need further exploration and learning outcomes following utilization (Foronda et al., 2017), including learner performance (Mendez et al., 2020).

Conclusion

AR can be used as a prebrief activity. While technical and usability issues occurred, participants found the AR prebrief activity effective per the high effectiveness scores for the prebrief phase in the follow-up simulation. Side effects may occur; however, they may be curbed by proper eye calibration. There are multiple factors for faculty to consider when integrating AR, regardless of its use during prebriefing.

Funding/Financial Disclosure

The research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sections. However, a technology (tech) grant was obtained from the University to purchase the head-mounted displays and pre-packaged scenarios used in the research. Additional support was received from CAE Healthcare. CAE Healthcare offered in-kind educational training and support on the HoloLens and AR application. See Acknowledgements.

Conflicts of Interest

More than one author has grants that are augmented reality related as well as patents not associated with this study or s manuscript . No other authors have reported conflicts of interest.

Acknowledgments

The authors acknowledge the The University of Central Florida for the Technology Fee grant used to purchase the equipment and scenarios and CAE Healthcare for their support. CAE Healthcare offered in-kind educational training and support on the HoloLens and AR application. In addition, some of this data was presented at the 2021 National League for Nursing Education Summit in Washington, DC, and at the International Meeting for Simulation in Healthcare (IMSH) 2022 Conference in Los Angeles, CA.

References

Aebersold, M., & Dunbar, D.-M. (2020). Virtual and augmented realities in nursing education: State of the science. In T. Schneidereith, & C. E. Kasper (Eds.). In *Annual Review of Nursing Research: 39(1)* (pp. 225–242). https://doi.org/10.1891/0739-6686.39.225.

Aebersold, M., & Schneidereith, T. (2020, October 20). *Extended reality: The future of nursing education* [Blog]. *NLN Nursing Edge*. Retrieved from https://nursingedge.nln.org/2020/10/20/extended-reality-the-future-of-nursing-education/ .

Aebersold, M., Voepel-Lewis, T., Cherara, L., Weber, M., Khouri, C., Levine, R., & Tait, A. R. (2018). Interactive anatomy-augmented virtual simulation training. *Clinical Simulation in Nursing*, *15*, 34-41. https://doi.org/10.1016/j.ecns.2017.09.008.

American Heart Association. (2020). *Figure 3. Algorithms: Adult cardiac arrest algorithm*. Retrieved from https://cpr.heart.org/en/resuscitation-science/cpr-and-ecc-guidelines/algorithms#adult.

Anderson, M., Guido-Sanz, F., Díaz, D. A., Lok, B., Stuart, J., Akinnola, I., & Welch, G. (2021). Augmented reality in nurse practitioner education: Using a triage scenario to pilot usability and effectiveness. *Clinical Simulation in Nursing*, *54*, 105-112. https://doi.org/10.1016/j.ecns.2021.01.006.

Bowman, D. A., & McMahan, R. P. (2007). Virtual reality: How much immersion is enough? *Computer*, *40*(7), 36-43. https://doi.org/10.1109/MC.2007.257.

Briese, P., Evanson, T., & Hanson, D. (2020). Application of Mezirow's transformative learning theory to simulation in healthcare education. *Clinical Simulation in Nursing*, *48*(C), 64-67. https://doi.org/10.1016/j.ecns.2020.08.006.

Brooke, J. (1996). SUS: A "quick and dirty" usability scale. In P. W. Jordan, B. Thomas, B. A. Werdmeester, & I. L. McClelland (Eds.), *Usability evaluation in industry* (pp. 189–194). London: Taylor & Francis.

Bye, B. J. D. (2014). Interactive pre-simulation strategies: Engaging students in experiential learning from the start. *Systematics, Cybernetics and Informatics*, *12*(1), 69-75.

CAE Healthcare. (n.d.). *CAE Ares: CAE AresAR*. Retrieved from https://www.caehealthcare.com/patient-simulation/ares/.

Carey, J. M., & Rossler, L. (2021, May 9). The how when why of high fidelity simulation. *StatPearls [Internet]* Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK559313/, May 8, 2022.

Cheng, A., Eppich, W., Epps, C., Kolbe, M., Meguerdichian, M., & Grant, V. (2021). Embracing informed learner self-assessment during debriefing: The art of plus-delta. *Advances in Simulation*, *6*, art. 22. https://doi.org/10.1186/s41077-021-00173-1.

Chmil, J. V. (2016). Prebriefing in simulation-based learning experiences. *Nurse Educator*, *41*(2), 64-65. https://doi.org/10.1097/NNE.0000000000000217.

Dang, B. K., Johnson, B. K., Butzlaff, A., Gilbert, G. E., Schleicher, M., Palicte, J., Wood, A. M., & Kardong-Edgren, S. (2021). A multi-site evaluation of observer roles and telepresence technology in simulation with prelicensure nursing students. *Clinical Simulation in Nursing*, *55*, 86-94. https://doi.org/10.1016/j.ecns.2021.03.007.

Der Sahakian, G., Alinier, G., Savoldelli, G., Oriot, D., Jaffrelot, M., & Lecomte, F. (2015). Setting conditions for productive debriefing. *Simulation and Gaming*, *46*(2), 197-208. https://doi.org/10.1177/1046878115576105.

Díaz, D., & Anderson, M. (2021). Structuring simulation-based education (SBE): From pre-simulation to debriefing. In P. R. Jeffries (Ed.), *Simulation in nursing education: From conceptualization to evaluation* (pp. 69–82). Washington, D.C.: National League for Nursing.

Dinkins, C. S., & Cangelosi, P. R. (2019). Putting Socrates back in Socratic method: Theory-based debriefing in the nursing classroom. *Nursing Philosophy*, *20*(2), e12240. https://doi.org/10.1111/nup.12240.

Foronda, C. L., Alfes, C. M., Dev, P., Kleinheksel, A. J., Nelson Jr, D. A., O'Donnell, J. M., & Samosky, J. T. (2017). Virtually nursing: Emerging technologies in nursing education. *Nurse Educator*, *42*(1), 14-17. https://doi.org/10.1097/NNE.0000000000000295.

Foronda, C. L., Crenshaw, N., Briones, P. L., Snowden, K., Griffin, M. A., & Mitzova-Vladinov, G. (2020). Teaching and learning the skill of intubation using telehealth glasses. *Clinical Simulation in Nursing*, *40*(C), 31-35. https://doi.org/10.1016/j.ecns.2019.12.005.

Fraser, K. L., Ayres, P., & Sweller, J. (2015). Cognitive load theory for the design of medical simulations. *Simulation in Healthcare*, *10*(5), 295-307. https://doi.org/10.1097/SIH.0000000000000097.

CleanBox. (n.d.). Website homepage for Cleanbox Technology, Inc. Retrieved from https://cleanboxtech.com.

Guido-Sanz, F., Anderson, M., Diaz, D., Mitzova-Vladinov, G., Aebersold, M., & Welch, G. (2022a). Extended reality in curricula: Setbacks and successes. *IMSH Society for Simulation in Healthcare* https://ssh.expoplanner.com/index.cfm?do=expomap.sess&event_id=15&session_id=5888.

Guido-Sanz, F., Anderson, M., Talbert, S., Diaz, D. A., Welch, G., & Tanaka, A. (2022b). Using simulation to test validity and reliability of I-BIDS: A new handoff tool. *Simulation & Gaming*. https://doi.org/10.1177/10468781221098567.

Hedrick, A. (2020, August). UVC light: Defining the facts, debunking the myths *[White paper]*. Cleanbox Technology, Inc Retrieved from https://cleanboxtech.com/wp-content/uploads/2020/11/UVC-Light-Defining-the-Facts-Debunking-the-Myths.CleanboxCollabWhitePaper.Aug2020.TO-PUBLISH-1-2.pdf .

Kardong-Edgren, S., Farra, S. L., Alinier, G., & Young, H. M. (2019). A call to unify definitions of virtual reality. *Clinical Simulation in Nursing*, *31*, 28-34. https://doi.org/10.1016/j.ecns/2019.02.006.

Kim, H. K., Park, J., Choi, Y., & Choe, M. (2018). Virtual reality sickness questionnaire (VRSQ): Motion sickness measurement index in a virtual reality environment. *Applied Ergonomics*, *69*, 66-73. https://doi.org/10.1016/j.apergo.2017.12.016.

Kotcherlakota, S., Pelish, P., Hoffman, K., Kupzyk, K., & Rejda, P. (2020). Augmented reality technology as a teaching strategy for learning pediatric asthma management: Mixed methods study. *JMIR Nursing*, *3*(1), e23963. https://doi.org/10.2196/23963.

Krippendorff, K. (2004). *Content analysis: An introduction to its methodology* (2nd ed.). Thousand Oaks: Sage.

LaViola, J. J., Jr., Kruijff, E., McMahan, R. P., Bowman, D., & Poupyrev, I. P (2017). *3D user interfaces: Theory and practice* (2nd). Boston: Addison-Wesley Professional.

Leigh, G., & Steuben, F. (2018). Setting learners up for success: Presimulation and prebriefing strategies. *Teaching and Learning in Nursing*, *13*(3), 185-189. https://doi.org/10.1016/j.teln.2018.03.004.

Leighton, K. (2018). Simulation program delivery models. In C. Foisy–Doll, & K. Leighton (Eds.), *Simulation champions: Fostering courage, caring, and connection* (pp. 85–108). Philadelphia: Wolters Kluwer.

Leighton, K., Ravert, P., Mudra, V., & Macintosh, C. (2015). Updating the Simulation Effectiveness Tool: Item modifications and reevaluation of psychometric properties. *Nursing Education Perspectives*, *36*(5), 317-323. https://doi.org/10.5480/15-1671.

Leighton, K., Ravert, P., Mudra, V., & Macintosh, C. (2018). *Simulation effectiveness tool–modified.* Evaluating Healthcare Simulation. Retrieved from https://sites.google.com/view/evaluatinghealthcaresimulation/set-m.

Lioce, L. (Ed.), Lopreiato, J. (Founding Ed.), Downing, D., Chang, T.P., Robertson, J.M., Anderson, M., Diaz, D.A., Spain A.E. (Assoc. Eds.) and the Terminology and Concepts Working Group (2020), Healthcare Simulation Dictionary Second Edition. Rockville, MD: Agency for Healthcare Research and Quality; September 2020. AHRQ Publication No. 20-0019. doi:10.23970/simulationv2.

Madden, K., & Carstensen, C. (2019). Augmented reality in nursing education. *Kai Tiaki Nursing New Zealand*, *25*(5), 28-29.

McCarthy, C. J., & Uppot, R. N. (2019). Advances in virtual and augmented reality-Exploring the role in health-care education. *Journal of Radiology Nursing*, *38*(2), 104-105. https://doi.org/10.1016/j.jradnu.2019.01.008.

McDermott, D. S. (2016). The prebriefing concept: A Delphi study of CHSE experts. *Clinical Simulation in Nursing*, *12*(6), 219-227. https://doi.org/10.1016/j.ecns.2016.02.001.

INACSL Standards Committee, McDermott, D. S., Ludlow, J., Horsley, E., & Meakim, C (2021, September). Healthcare Simulation Standards of Best Practice^{TM} Prebriefing: Preparation and briefing. *Clinical Simulation in Nursing*, *58*, 9-13. https://doi.org/10.1016/j.ecns.2021.08.008.

Mendez, K. J. W., Piasecki, R. J., Hudson, K., Renda, S., Mollenkopf, N., Nettles, B. S., & Han, H.-R. (2020). Virtual and augmented reality: Implications for the future of nursing education. *Nurse Education Today*, *93*, 104531. https://doi.org/10.1016/j.nedt.2020.104531.

Mezirow, J. (2000). Learning to think like an adult: Core concepts of transformation theory. In J. Mezirow, et al. (Eds.), *Learning as transformation: Critical perspectives on a theory in progress* (pp. 3-33). San Francisco, CA: Jossey-Bass.

Microsoft. (2019). *HoloLens Tips*. Retrieved from https://www.microsoft.com/en-us/p/hololens-tips/9pd4cxkklc47#activetab=pivot:overviewtab.

Microsoft. (2019). *HoloLens 2*. Retrieved from https://www.microsoft.com/en-us/hololens/buy.

Nye, C., Campbell, S. H., Hebert, S. H., Short, C., & Thomas, M. (2019). Simulation in advanced practice nursing programs: A North-American survey. *Clinical Simulation in Nursing*, *26*(C), 3-10. https://doi.org/10.1016/j.ecns.2018.09.005.

Shin, H., Rim, D., Kim, H., Park, S., & Shon, S. (2019). Educational characteristics of virtual simulation in nursing: An integrative review. *Clinical Simulation in Nursing*, *37*(C), 18-28. https://doi.org/10.1016/j.ecns.2019.08.002.

INACSL Standards Committee, Watts, P. I., McDermott, D. S., Alinier, G., Charnetski, M., Ludlow, J., Horsley, E., Meakim, C., & Nawathe, P. A ((2021, September)). Healthcare Simulation Standards of Best Practice^{TM} Simulation Design. *Clinical Simulation in Nursing*, *58*, 14-21. https://doi.org/10.1016/j.ecns.2021.08.009.

The National Organization of Nurse Practitioner Faculties and American Association of Colleges of Nursing. (2016). *Adult-gerontology acute care and primary care NP competencies*. Retrieved from https://cdn.ymaws.com/www.nonpf.org/resource/resmgr/files/np_competencies_2.pdf.

Tyerman, J., Luctkar-Flude, M., Graham, L., Coffey, S., & Olsen-Lynch, E. (2016). Pre-simulation preparation and briefing practices for healthcare professionals and students: A systematic protocol. *JBI Database of Systematic Reviews and Implementation Reports*, *14*(8), 80-89. https://doi.org/10.11124/JBISRIR-2016-003055.

Tyerman, J., Luctkar-Flude, M., Graham, L., Coffey, S., & Olsen-Lynch, E. (2019). A systematic review of health care presimulation preparation and briefing effectiveness. *Clinical Simulation in Nursing*, *27*(C), 12-25. https://doi.org/10.1016/j.ecns.2018.11.002.

U.S. General Services Administration, Technology Transformation Services. (n.d.). *System usability scale*. Usability.gov. Retrieved from https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html.

Vaughn, J., Lister, M., & Shaw, R. J. (2016). Piloting augmented reality technology to enhance realism in clinical simulation. *CIN: Computers, Informatics, Nursing*, *34*(9), 402-405. https://doi.org/10.1097/cin.0000000000000251.

Weintraub, A. Y., Deutsch, E. S., Hales, R. L., Buchanan, N. A., Rock, W. L., & Rehman, M. A. (2017). Using high-technology simulators to prepare anesthesia providers before implementation of a new electronic health record module: A technical report. *Anesthesia & Analgesia*, *124*(6), 1815-1819. https://doi.org/10.1213/ANE.0000000000001775.

Wüller, H., Behrens, J., Garthaus, M., Marquard, S., & Remmers, H. (2019). A scoping review of augmented reality in nursing. *BMC Nursing*, *18*(1), art. 19. https://doi.org/10.1186/s12912-019-0342-2.

Zhu, E., Hadadgar, A., Masiello, I., & Zary, N. (2014). Augmented reality in healthcare education: An integrative review. *PeerJ*, *2*, e469. https://doi.org/10.7717/peerj.469.

Gaumard® Scientific. (n.d.). *Meet the versatile HAL® S3201 advanced multipurpose patient simulator*. Retrieved from https://www.gaumard.com/advanced-hal-s3201. Manuscript In Press.