The Use of Immersive and Virtual Reality Technologies to Enable Nursing Students to Experience Scenario-Based, Basic Life Support Training—Exploring the Impact on Confidence and Skills

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The link between effective basic life support and survival following cardiac arrest is well known. Nurses are often first responders at in-hospital cardiac arrests and receive annual basic life support training to ensure they have the adequate skills, and student nurses are taught this in preparation for their clinical practice. However, it is clear that some nurses still lack confidence and skills to perform basic life support in an emergency situation. This innovative study included 209 participants, used a mixed-methods approach, and examined three environments to compare confidence and skills in basic life support training. The environments were nonimmersive (basic skills room), immersive (immersive room with video technology), and the Octave (mixed reality facility). The skills were measured using a Laerdal training manikin (QCPR manikin), with data recorded on a wireless Laerdal Simpad, and confidence levels before and after training were measured using a questionnaire. The nonimmersive and the immersive rooms were familiar environments, and the students felt more comfortable, relaxed, and, thus, more confident. The Octave offered the higher level of simulation utilizing virtual reality technology. Students felt less comfortable and less confident in the Octave; we assert that this was because the environment was unfamiliar. The study identified that placing students in an unfamiliar environment influences the confidence and skills associated with basic life support; this could be used as a way of preparing student nurses with the necessary emotional resilience to cope in stressful situations.

KEY WORDS: Clinical skills, Competence, Confidence, Student nurses, Virtual reality

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BACKGROUND, SIGNIFICANCE, AND PURPOSE

Cardiac arrest requires effective basic life support (BLS). Basic life support refers to the maintenance of airway patency, supporting breathing and circulation,[1] and is a vital element in the chain of survival (early recognition, high-quality BLS, prompt defibrillation, and effective postresuscitation care).[2] However, many student nurses lack confidence in their ability to carry out this skill.[3] Traditionally, BLS training follows behavioristic and experiential educational learning theories concentrating on developing psychomotor skills, mainly using low-fidelity simulation (LFS) equipment.[4] Nevertheless, LFS has limited capability to create sufficient realism, and as novice nurses lack the ability and experience to create a clear mental picture in simulation,[5] this causes a barrier to learning. Hence, the use of medium-fidelity simulation equipment is now more common place within BLS training[6]; some research utilizes high-fidelity simulation (HFS) equipment.[7] Medium-fidelity simulation is increasingly used due to its ability to develop the learner's cognitive as well as psychomotor skills with the analysis of skills such as hand positioning and chest compression depth,[8] and appears to be a key component in the improvement of the associated skills. High-fidelity simulation allows learners to develop essential skills such as team working and communication skills. This method follows a constructivist approach to educational theory by allowing the participants to actively engage in realistic scenarios and gain instant feedback. It is well known that different levels of simulation assist with skill acquisition and maintenance of skills competence[3]; thus, introducing virtual reality (VR) as a form of HFS could enhance the competence and confidence gained during the BLS training.

The deficit in confidence[9,10] and competence (skills)[5,6,9] associated with BLS is well known, and some literature suggests that an increase in the ability to do the practical skills equates to an increase in confidence.[10] Basic life support is a major issue of global concern,[11,12] with approximately 200 000 in-hospital incidents in a year reported.[11] Based on the fact that student nurses work in clinical environments where they are directly involved in caring for acutely ill patients, it is essential that they receive BLS training that equips them with adequate skills and confidence. Nurse educators must strive to equip students with the necessary skills to deliver BLS under pressure. The new challenges and requirements in nursing practice and education have called for alternative teaching strategies.[13] The international research of Creutzfeldt et al[12] conducted in the United States and Sweden using avatars for BLS training emphasized the need for new, engaging learning methods. Driving forces, such as patient safety and limited clinical placement areas, have also increased the need to incorporate technology-driven simulation into nursing education programs, and integrating new technologies and levels of simulation has been viewed as crucial in bridging the theory and practice gap.[13] Simulation and VR technology have gained significant attention within the healthcare and medical education industries around the world within recent years.[14,15]

This study explored the use of immersive VR technologies to enable nursing students to experience scenario-based cardiopulmonary resuscitation (CPR) training. Virtual reality systems allow high levels of immersion (the psychological response to the technology)[16] and presence (the subjective experience of being in a place or in an environment, even if physically in another environment).[16] Today, affordable head-mounted displays (HMDs) such as the Oculus Rift Oculus; Facebook, Menlo Park, CA are typically associated with VR; however, more expensive large-scale projected display technologies are also available. These spatially immersive displays allow more than one user to physically occupy the environment, rendering a convincing and optically correct graphical environment for one of the users. The Octave system used in the study is an example of a spatially immersive VR system.[17] One key benefit of such spatially immersive displays is that the users can see their own body, leading to less cognitive dissonance than head mounted systems and facilitating smoother physical interactions. This also allows physical items to be handled by the users (in this case a CPR manikin). This support for real objects is a key differentiator of these systems in the context of this experiment, leading to the term "augmented virtuality."[18]

Immersion in the scenario allows students to practice the skills using the manikin in a safe environment. This enables risk-free learning in complex situations and promotes team-based and interdisciplinary approaches to learning in healthcare.[19] An American study by Rizzo and Kim[20] suggested that in some cases, it can be useful not to copy reality exactly in VR, for example, time-consuming tasks to be better simulated. Often, students may have limited exposure to patients in emergency situations,[21] and VR simulation–based training applications allow high-fidelity repetition of tasks that could improve responder skills through exposure to clinical scenarios.[22] The use of simulation manikins allows haptic feedback to be experienced by the user. In an Italian study by Semeraro et al,[23] both a simulation system and VR environment were used to create a more realistic training environment for CPR. Contrary to this study, they used an HMD and participants were therefore encumbered and disassociated, which is not helpful when developing clinical skills. Virtual reality simulation is thought to be an effective approach for skills preparation, particularly in relation to communication, critical thinking, and collaboration.[9,24] Studies have illustrated the positive effect of VR on clinical skill performance,[24] emphasizing the usefulness of this method of simulation in nurse education.

While the use of VR for skills teaching is not a new concept, dating back to aviation flight simulations during the 1960s,[13] it seems that this kind of VR simulation for student nurse education is novel, allowing intricate clinical skills to be practiced without the risk of harming patients in clinical settings.[24] Virtual reality in BLS training has the potential to enhance the delivery of the training and provide a more realistic learning environment that challenges the students' confidence and skills. This ultimately can prepare the students for a "real-life" cardiac arrest, when they will need to use the BLS skills in what is often a traumatic testing situation. It is envisaged that the use of higher-fidelity simulation such as VR and immersive environments should test the confidence and their ability; repeated exposure could better prepare them to cope in the real situation.

RESEARCH QUESTION

The purpose of this study was to explore the use of immersive VR technologies in an unfamiliar environment for the students (The Octave), compared to the familiar environments of the immersive video technology and nonimmersive clinical skills room. The objective was to enable nursing students to experience scenario-based BLS training in these varying environments and to analyze the effect that these facilities have on the confidence and competence (skills) of the student nurses during BLS training.

METHODS

This innovative project used a mixed-methods approach and was created and delivered by members from the School of Health and Society, the Thinklab, and the School of Computer Sciences. Ethical considerations were adhered to and institutional ethical approval was granted by the Research and Ethics committee at the university. The study included the use of three different environments:

1. Nonimmersive—a standard basic the skills room (see Figure 1)
2. The immersive simulation room which employs fixed view point 360° video and stereo sound (see Figure 2)
3. The state-of-the-art Octave suite offering the highest level of immersion and interaction within a mixed virtual and real space (see Figure 3)

In total, 208 participants were included in the study (nonimmersive, n = 55; immersive, n = 73; Octave, n = 80).

Study Design

The study gathered quantitative data from the Laerdal QCPR manikin (Laerdal Medical, Stavanger, Norway) and the prevalidated confidence questionnaire. Some qualitative data were obtained and analyzed from the postsession questionnaire.

Before the study, the data collection tool was tested for validity and reliability. The study was carried out in the university using purposive sampling, a deliberate nonrandom method, which aims to sample a specific group of people. Participants were in their second year of a 3-year course. Therefore, they had already had some training in the first year; this session was an update for their knowledge and skills. Informed consent was obtained prior to inclusion in the study, and participants were made aware of the purpose and methods of the research study and their right to withdraw at any time via the participant information sheet, which was distributed prior to the study. Participants were also assured of confidentially and anonymity. All participants completed the same BLS refresher training before practicing their BLS skills on the QCPR manikin in one of the three environments and completed the same pretraining and posttraining questionnaires. Table 1 provides a clear outline of the research process in each of the three environments.

The Environments

The three different environments and levels of simulation allowed us to compare the BLS performance and confidence of the learners. The basic skills room had no added technology; it has hospital beds and lockers and imitates a ward environment. The immersive simulation room, in comparison, uses video technology, which projects realistic images onto the wall, with audio. The suite is fully fitted with an audiovisual system that allows scenarios to be streamed, recorded, and played back. It is a discrete, multicamera and microphone system by which different views can be achieved. This was also set up to present an outdoor urban environment

FIGURE 1. The Non immersive – standards skills room environment.

FIGURE 2. The immersive simulation room.

that included streets, houses, and associated distractions and dangers such as road traffic. The "Octave" VR facility is an octagonal space with a maximum diameter of approximately 6 m (18 feet) surrounded by stereo wall and floor projection. This provides high-end simulation, integrating nurse training and associated props with a realistic visual and aural sensation of an outdoor urban environment that included streets, houses, and associated distractions and dangers such as road traffic. This system tracks the position of the user's head and uses shutter glasses to present three-dimensional (3D) visual cues while allowing users to walk around and interact with virtual objects within in a real space. Mounted around the top of the projection screens is an octagonal ring of 128 loudspeaker units controlled by a dedicated acoustic rendering system employing wave field synthesis. The visual and audio systems were hence linked to align visual and audio cues. The system employed novel techniques to visually and acoustically render moving objects, giving a very realistic experience of nearby traffic.[25] The Octave system's capability as an "augmented virtuality"[18] allows freedom of movement, and several users can collaborate and naturally communicate with each other within the space while experiencing real and rendered sounds from their own perspectives and thus is very useful in BLS training.

Data Collection

Collection of qualitative data regarding confidence levels was performed using an adapted version of a prevalidated confidence tool.[26] Permission was sought from and granted

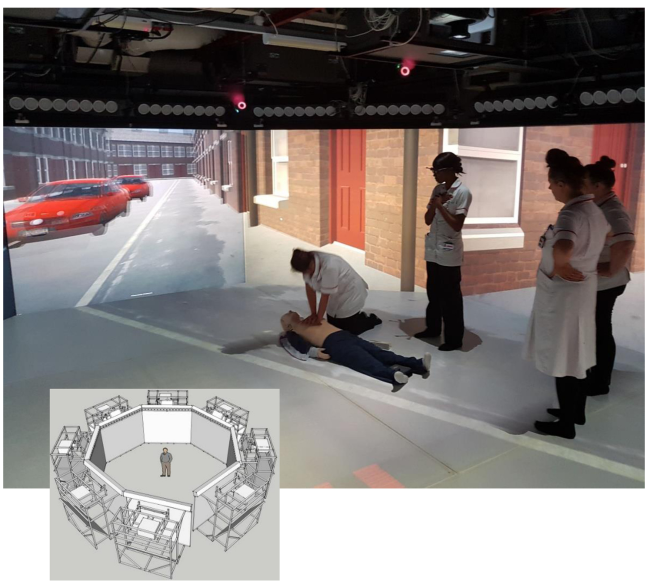

FIGURE 3. The Octave virtual environment facility.

Table 1. Outline of Research Process

Basic Skills Room	Immersive Room	Octave
Consent forms completed	Consent forms completed	Consent forms completed
Pre-BLS confidence questionnaire completed	Pre-BLS confidence questionnaire completed	Pre-BLS confidence questionnaire completed
Instructor facilitated BLS update to refresh knowledge in a standard classroom	Instructor facilitated BLS update to refresh knowledge in a standard classroom	Instructor facilitated BLS update to refresh knowledge in a standard classroom
Demonstration of BLS	Demonstration of BLS	Demonstration of BLS
Students practiced on manikins	Students practiced on manikins	Students practiced on manikins
Students went into the basic clinical skills room and practiced in pairs	Students went into the immersive room in pairs	Students went into the Octave in pairs
Presented with a scenario	Presented with a scenario	Presented with a scenario
The facilitator had to say what was happening in the scenario as the environment could not be changed. Patient (manikin) collapsed on the pavement on a street	Patient (manikin) was collapsed on the pavement on a street	Patient (manikin) was collapsed on the pavement on a street
	Students were in the immersive and could see the street and hear noises on the video	Students were in the Octave environment and could see the street and cars going past and had sounds, felt like they were in the middle of it
Each student performed CPR then swapped over	Each student performed CPR then swapped over	Each student performed CPR then swapped over
Laerdal QCPR manikin was connected to provide skills feedback	Laerdal QCPR manikin was connected to provide skills feedback	Laerdal QCPR manikin was connected to provide skills feedback
Post-BLS confidence questionnaire completed	Post-BLS confidence questionnaire completed	Post-BLS confidence questionnaire completed
Debrief and evaluation of learning	Debrief and evaluation of learning	Debrief and evaluation of learning

by the original author for the use of some aspects of the original tool. The validity and reliability of this were tested during the pilot study. A total of 36 students took part in the pilot study and enabled the researchers to confirm that the design was fit for purpose.

The pre–training session questionnaire consisted of a 10-item Likert scale design (0%–100% confidence), so participants could self-evaluate their confidence levels in relation to performing the different steps required in BLS; these included ability to establish responsiveness, call for help, assess airway, initiate CPR, and follow BLS guidelines. The postsession questionnaire consisted of the same 10 items for students to self-report their confidence levels. This questionnaire also included some general comments boxes, which provided some qualitative data regarding the session and the environment.

Quantitative data were obtained using a Laerdal Sim Pad and QCPR manikin, which provided electronic data for each individual, regarding the participants' skills performance, including an overall BLS score, compression score, ventilation score, and data regarding compressions and ventilations.

Data Analysis

Data analysis of the quantitative data was performed using IBM SPSS Statistics version 23 (IBM, Armonk, NY) (see Table 2). Nonparametric statistics were analyzed using Wilcoxon/Mann Whitney U and medians. P values were calculated to indicate statistical significance of the findings (see Table 2). The responses from the open questions on the postcourse questionnaire were analyzed and manually coded using content analysis, revealing themes in the data. During this process, the research team referred back to the aim of the study to ensure the focus remained. Participants with single missing data were excluded from the analysis.

Statistical comparisons were made using the nonparametric analysis of variance (ANOVA) and Kruskal Wallis tests to determine if there were any statistically significant differences between the groups of the independent variables.

RESULTS

Qualitative Data

Verbatim comments from the postsession questionnaire provided qualitative data regarding the environment in which the BLS training had taken place, the equipment used, things that the participants liked and disliked about the training, and the overall concept.

Regarding the environment, no participants commented on the realism of the environment in the skills room; the skills room was reported to be a "relaxed environment" (n = 7). The immersive environment was reported to give an "insight into real-life situation/more realistic" (n = 23). However, a majority of the participants (n = 27) commented specifically on the realism in the Octave, with others commenting on how "lifelike" it was (n = 4).

Table 2. Parametric and Nonparametric Evaluation of Competence and Confidence Scores (Laerdal Sim Pad QCPR Manikin)

Competence Skills Score—Parametric Evaluation				
Measure	**pAnova**	**MeanNon**	**MeanImmersive**	**MeanOctave**
score1	0.0407	46.6	46.9	37.1
compressionscore	0.0589	35.9	43.4	30.9
ventilationscore	0.0795	92.2	93.6	87.1
numbercycles	0.7123	1.9	1.8	1.8
compressionhandpos	0.0011	92.5	83.5	72.7
numbercompress	0.6031	83	81.7	83.7
meancompdepth	0	41.2	48	41.4
totalventilation	0.0687	3.7	3.8	3
meanventvol	0.2922	502.4	439	449.6
Confidence Tool—Parametric Evaluation				
Measure	**pAnova**	**MeanGainNon**	**MeanGainImmersive**	**MeanGainOctave**
Unres1-Unres	0.592	12.1	12.1	10.3
Pulseness1-Pulseness	0.3835	9	7	9.7
Help1-Help	0.2955	3.3	2.3	4.6
CPR1-CPR	1.00E-04	28.8	15.8	20.9
Ventilation1-Ventilation	6.00E-04	26.3	14.9	17
Bag1-Bag	0	29.2	14.8	15
BLS1-BLS	0	24.3	12.3	13.4
Leadership1-Leadership	0.0163	27.7	17.7	19.3
Asystole1-Asystole	0.5849	16.9	13.9	17.2
Nonparametric Evaluation of Scores				
Competence Skills Score (using Laerdal Sim Pad QCPR Manikin)—Nonparametric Evaluation				
Measure	**pKruksall**	**MedianNon**	**MedianImmersive**	**MedianOctave**
score1	0.0514	45	41	32
compressionscore	0.0426	31.5	44.5	27
ventilationscore	0	100	100	93
numbercycles	0.862	2	2	2
compressionhandpos	2.00E-04	100	100	93
numbercompress	0.9956	86	89	86
meancompdepth	1.00E-04	43	48	43
totalventilation	0.1357	4	4	4
meanventvol	0.0638	574.5	498	550
Confidence Tool—Nonparametric Evaluation				
Measure	**pKruksall**	**MedianGainNon**	**MedianGainImmersive**	**MedianGainOctave**
Unres1-Unres	0.6207	10	10	10
Pulseness1-Pulseness	0.2929	10	5	10
Help1-Help	0.9287	0	0	0
CPR1-CPR	0.0012	25	10	20
Ventilation1-Ventilation	0.0066	25	10	15
Bag1-Bag	0	30	10	15
BLS1-BLS	0.0024	20	10	10
Leadership1-Leadership	0.181	20	20	20
Asystole1-Asystole	0.5481	10	10	12.5

The equipment gained positive feedback, with participants commenting on the "equipment being available" (n = 4) and the fact that the manikins were "good" (n = 8) and useful (n = 4) in the skills room; however, in the Octave, most participants seemed to comment that the "equipment was modern" (n = 7) and "very good" (n = 10).

Participants liked the "team scenarios" (n = 8) and the ability to "practice on models" (n = 5); however, the Octave group commented on how they "liked the reality of the virtual street" (n = 14) and the fact that it was "more realistic than a classroom" (n = 12) (n = 26 total), presumably basing their opinion on the BLS session that they had the previous year. Overall, the participants reported liking the "reality of the Octave," which was superior (n = 26) to the other two areas, with the immersive group commenting on the "reality of the environment" (n = 18) but that they "felt more relaxed" and that they felt "relaxed and less pressure" (n = 5); perhaps as this is in the nursing simulation suite, this is more familiar environment.

Fundamentally, participants enjoyed the sessions; however, some respondents in the skills room reported the scenarios to be "daunting" and "disliked the interactions with manikins." The Octave group (n = 4) said that they felt "dizzy when they came out" and some participants reported feeling "overwhelmed" and "did not like adjusting to the new environment" (n = 8). In the main, there were only a few things that participants did not like in the groups. The new environment (the Octave) was not known to the students as it is located in a building that student nurses do not use, unlike the skills room and the immersive environment, which are housed in a familiar setting.

In response to their opinion about the overall concept, participants in the nonimmersive (skills) room felt that this environment was "good, increasing knowledge, and giving them more chance to practice" (n = 10). In the immersive environment, participants felt that the overall concept in this area was good (n = 14), very good (n = 5), or excellent (n = 2), with some students reporting "feeling more confident" (n = 5).

Participants in the Octave commented that it was "a very good learning environment" (n = 24), which would make them more confident in a real situation (n = 19), with one saying that the session was "Excellent please can this be introduced and available as soon as possible. Life like environment has evoked emotions such as panic and will help us to develop skills that will enable us to cope with challenging circumstances," and another saying, "Placing students in an environment as realistic as possible may help to develop their emotional intelligence, physical and clinical qualities required to deal with emergency situations."

Three of the participants specifically commented on the usefulness of this novel environment (the Octave) in the sense that it is "testing and challenging," with one commenting, "A brilliant idea, made me more aware of myself, learned more in that short time than sat in a skills room."

Quantitative Data

Quantitative data were obtained from the confidence tool questionnaire and the QCPR manikin, which provided electronic data. The following results show the evaluation of 209 student scores (non I = nonimmersive environment, I = immersive environment, and Oct = Octave environment). Table 2 shows the parametric statistics, which is applicable given that the corresponding Shapiro-Wilk normality tests confirm that we cannot reject the hypothesis that the sample comes from a population that has a normal distribution (eg, for score 1, Shapiro-Wilk $W = 0.95774$, $P = 7.663e\text{-}06$). With a one-way assessment of variance (ANOVA), the results show that the mean overall scores (score 1) are significantly lower within a fully immersive "Octave" space when compared to nonimmersive and semi-immersive scenarios. Table 2 also shows the corresponding nonparametric evaluation with median scores, and a Kruskal-Wallis one-way ANOVA gave similar results.

Gain scores were also calculated (ie, differences between the means of the participants' recorded confidence levels before and after performing the given task) (see Table 2, Figure 4 and Figure 5). Typically, those confidence measures with significant differences show that the confidence gains are higher in the nonimmersive environments.

It is expected that within fully immersive environments, there will be a detrimental impact on the student's ability to formulate tasks and feel confident in accomplishing those tasks. The environment recreated the dynamic 3D visuals and 3D sounds of traffic threats and other real-world distractions. Given the high presence and ecological validity of the Octave system, it could be argued that using such a space for training gives the students a more realistic self-assessment of their performance in a realistic context and, hence, better preparation for the real world. However, to some extent, the mediating technology could also be a distraction (eg, wearing 3D spectacles and the wow factor of the space).

Competence and Skills

Parametric competence scores showed a statistically significant result ($P = .04$), with mean overall BLS scores of 46.6 for non I, 46.9 for I, and 37.1 for Oct, showing that, overall, participants were more competent in the immersive suite. Similarly, participants in the immersive environment gained significantly better results than in the other areas, when achieving compression depth, with mean scores of 48 in comparison to 41.2 in non I and 41.4 in the Octave. Conversely, the nonimmersive environment proved more successful for

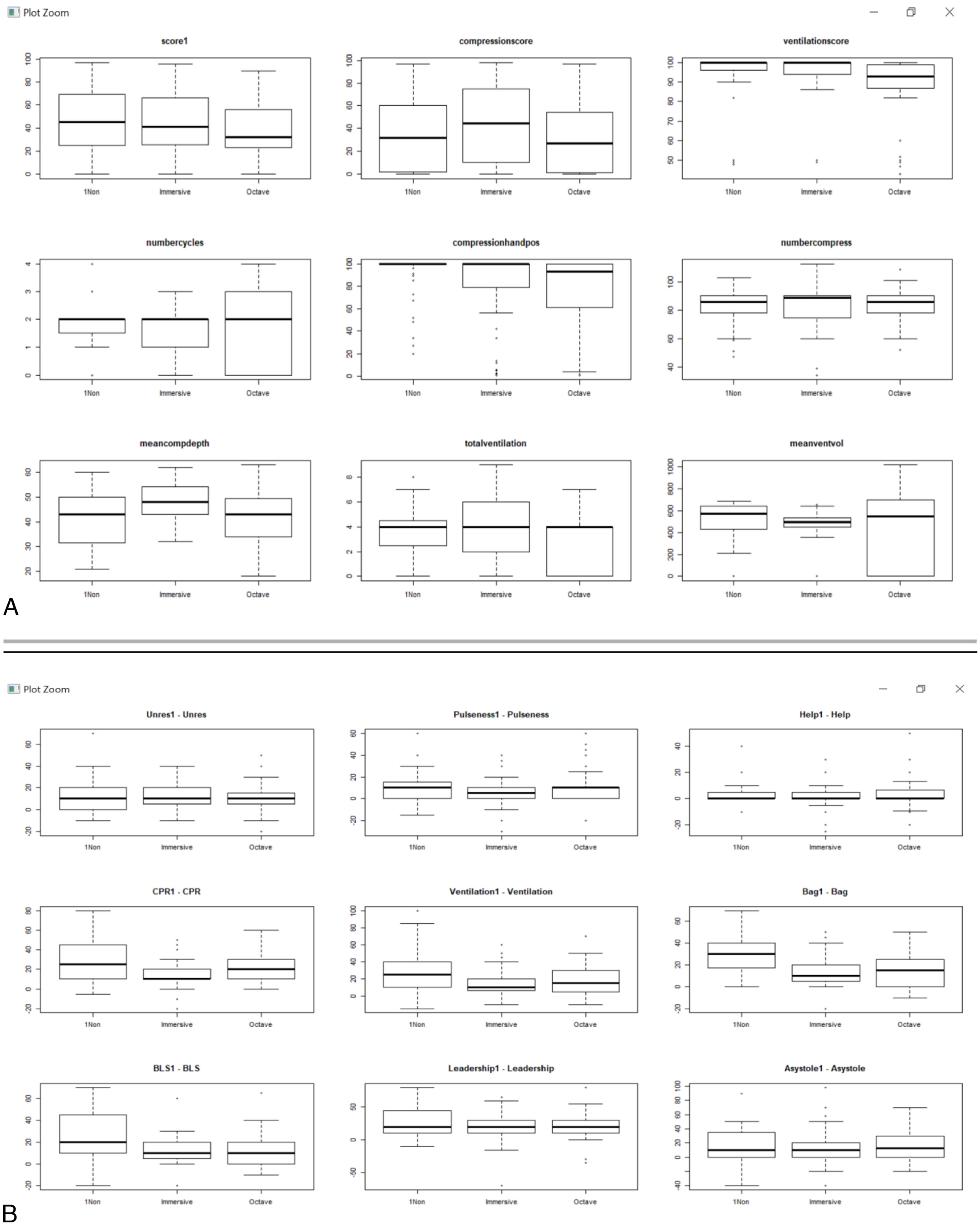

FIGURE 4. Objective scores from the Laerdal Sim pad QCPR manikin (A) and confidence questionnaire (B).

hand position, with mean scores of 92.5 for non I, 83.5 for I, and 72.7 for Oct ($P = .0011$).

Nonparametric evaluation of competence scores revealed only the difference in compression scores to be statistically significant (31.5 for non I, 44.5 for I, and 27 for Oct) ($P = .0426$), again revealing the immersive suite to be better in gaining skill adequacy, potentially due to the familiar surroundings, but with an added element of realism.

Confidence

Parametric gain statistics (see Table 2, Figure 4) for confidence levels reveal three measures that show a statistically significant gain score; these were the use of the bag valve mask ventilation, the ability to follow BLS guidelines, and confidence in establishing a leadership role in BLS situations. These three measures found the nonimmersive environment to have the greatest gain in confidence. Bag valve mask

pT-Test (Non-Immersive/Immersive) Skills

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p<0.05 results significant)

Measure             pAnova  pKruksall pT-Test(Non-I/I)

 [1,] "score1"            "0.041" "0.051"   "0.0573542295"
 [2,] "compressionscore"   "0.059" "0.043"   "0.3727524033"
 [3,] "ventilationscore"   "0.079" "0"       "0.1283885213"
 [4,] "numbercycles"       "0.712" "0.862"   "0.41236315"
 [5,] "compressionhandpos" "0.001" "0"       "0.0001090933"
 [6,] "numbercompress"     "0.603" "0.996"   "0.7150312084"
 [7,] "meancompdepth"      "0"     "0"       "0.9076326856"
 [8,] "totalventilation"   "0.069" "0.136"   "0.066716778"
 [9,] "meanventvol"        "0.292" "0.064"   "0.2136896331"
```

A

pT-Test(Non-Immersive/Octave)

```
 pT-Test(Non-I/Octave)
 [1,] "0.9494461685"
 [2,] "0.2171418826"
 [3,] "0.6333572635"
 [4,] "0.4764439926"
 [5,] "0.0435032398"
 [6,] "0.5877791744"
 [7,] "0.0001682605"
 [8,] "0.6823014973"
 [9,] "0.0610355296"
```

B

pTTest Non Immersive/ Immersive - Non Immersive/ Octave- Confidence

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Measure                   pAnova  pKruksall pT-Test(Non-I/I) pTTest(NonI/Octave)
 [1,] "Unres1 - Unres"            "0.592" "0.621"   "0.3805153699"
"0.5583797713"
 [2,] "Pulseness1 - Pulseness"    "0.383" "0.293"   "0.1509575965"
"0.8710965886"
 [3,] "Help1 - Help"              "0.296" "0.929"   "0.0482902322"
"0.4679773898"
 [4,] "CPR1 - CPR"                "0"     "0.001"   "0.1738164981"
"0.0429137049"
 [5,] "Ventilation1 - Ventilation" "0.001" "0.007"   "0.3511509866"
"0.1843508043"
 [6,] "Bag1 - Bag"                "0"     "0"       "0.0958954257"
"0.1063569683"
 [7,] "BLS1 - BLS"                "0"     "0.002"   "0.0550334988"
"0.0103217358"
 [8,] "Leadership1 - Leadership"  "0.016" "0.181"   "0.0195399608"
"0.0124452777"
 [9,] "Asystole1 - Asystole"    "0.585" "0.548"  "1.7294e-06" "1.0414e-06"
```

C

FIGURE 5. pT-test: (A) nonimmersive/immersive skills; (B) nonimmersive/Octave; (C) nonimmersive/immersive-nonimmersive/Octave-confidence.

ventilation showed gain scores of 29.2 for non I, 14.8 for I, and 15 for Oct ($P < .001$). The confidence at being able to follow BLS guidelines showed gain scores of 24.3 for non I, 12.3 for I, and 13.4 for Oct ($P < .001$), and the confidence in establishing a leadership role, 27.7 for non I, 17.7 for I, and 19.3 for Oct ($P = .0163$), perhaps highlighting the importance of LFS in the development of associated skills; yet interestingly, the Octave environment showed a slightly better gain than the immersive environment. Perhaps the participants felt more confident testing their knowledge and skills in an unfamiliar environment; adversely, the fear of the unknown before the training in the unfamiliar setting and the realization after the training that it was not as bad as expected may have increased their confidence gain significantly.

Nonparametric testing gain scores revealed the ability to initiate CPR, perform bag mask ventilation, and follow BLS guidelines as the measures that showed statistically significant gain in confidence. The nonimmersive environment showed the greatest gain score for confidence in initiating CPR (25 for non I, 10 for I, and 20 for Oct) ($P = .0012$), performing bag valve ventilation (25 for non I, 10 for I, and 15 for Oct) ($P = .0066$), and following BLS guidelines (20 for non I, 10 for I, and 10 for Oct) ($P = .0024$). Similar findings in two of the measures (initiating CPR and performing bag valve ventilation) reveal that the Octave was more successful in participants' confidence gain than the immersive suite.

We can infer from the results that if learners continue to be exposed to VR training, their confidence will increase, or it could be argued that if they had repeated exposure to this new environment, it would lose the ability to test their skills in a challenging unfamiliar environment.

DISCUSSION

The findings from this study have provided interesting thoughts regarding the challenges that learners may need to prepare them adequately for the many unfamiliar and challenging situations they may find themselves in as student nurses in clinical practice. The findings can also be generalized to students and learners in other disciplines globally.

Competence and Skills

The parametric competence scores showed that, overall, participants were more competent in the immersive suite. Similarly, participants in the immersive environment gained significantly better results than in the other areas when achieving compression depth. Interestingly, the nonimmersive environment proved more successful for hand position. Nonparametric evaluation of competence scores revealed only the difference in compression scores to be statistically significant, again revealing the immersive suite to be better in gaining skill adequacy, potentially due to the familiar surroundings, but with an added element of realism. For skill acquisition, it would appear that the Octave scored lower than the other two environments. Perhaps this is due to distracting elements within the environment and the fact that it was unfamiliar to the participants; perhaps, the added technology and features bring with them sensory overload, affecting the participants' ability to perform, ultimately affecting their competence. Although the immersive suite has added technology, on a lesser scale, it is in an environment that is familiar to the students. Technology, it seems, can act as a distraction and a barrier to learning in some cases with an often intrinsic resistance to change. Khalil[27] discussed this resistance and the fact that this can be a barrier to utilizing the enhanced facilities, not just for the students but the staff as well.[27]

The unfamiliar environment (Octave) was more challenging for the participants, with verbatim comments revealing that they felt overwhelmed. They commented that the "Octave was a new environment and that they needed to adjust." Nevertheless, there appeared to be the understanding that this unfamiliarity would help them to prepare and increase their confidence in a real situation. Indeed, recent literature has highlighted the anxiety linked with such game technology.[28] This has been criticized for focusing on cognitive learning outcomes, often ignoring the emotional aspects of learning, which of course can also significantly contribute to learning, student performance, and motivation.[28] Recent study findings[28] indicate that using such technology resulted in some participants experiencing less positive emotions, which included anxiety, nervousness, fear, and stress. Conversely, this type of technology can be praised for providing a more dynamic and engaging learning experience, which is more memorable and useful particularly in line with visual learning styles.

With this in mind, the more enhanced technology associated with the Octave located in an unfamiliar environment is much more likely to test the confidence and the skills of those performing BLS, and arguably, this could be a perfect way of preparing the student nurses for the challenges in clinical practice that may face them, by taking them out of their "comfort zone" of the familiar skills room and utilizing an area such as the Octave. Indeed, this facility is not easily accessible and requires costly equipment, yet it is hoped that the technology associated with it can be transferred to a more accessible means as it is without doubt a valuable resource for learning. The challenges associated ahead of critical care placements are documented; students often lack knowledge and confidence in these areas.[29] It is recognized that nurse education should utilize a variety of methods to ensure that nurses are competent and confident for clinical practice[30] and that more creative solutions to teaching may lessen the "fear of the unknown."[31]

The "familiar" environments (nonimmersive, immersive) seemed to make the students feel more comfortable, with verbatim comments concluding that they felt more "confident/relaxed" at the time of training. The nonimmersive room was also reported to be a "more relaxed environment," providing a conclusion as to why the students reported to be more confident in those areas, in keeping with the quantitative findings of the study. As the immersive suite utilizes video technology, this is a relatively more cost-effective and an easily accessible solution.

Confidence

Self-confidence in the ability to carry out nursing duties is crucial to effective performance, and clinical skills performance has been reported to be the most influential source of confidence in nurses.[30] The parametric gain statistics for confidence levels revealed three measures that show a statistically significant gain score; these were the use of the bag valve mask ventilation and ability to follow BLS guidelines and establish a leadership role in BLS situation. These three measures found the nonimmersive environment to have the greater gain. Yet interestingly, the Octave environment showed a slightly better gain than the immersive environment. It is understandable that a nonimmersive, familiar, nonthreatening environment would make students feel more comfortable and confident. With higher levels of simulation comes the risk of initiating feelings of fear within the learner, which will in turn affect confidence levels. Yet interestingly, the Octave, which uses advanced technology, shows a better gain of confidence than the immersive environment. Perhaps this can be equated to the "fear of the unknown" and is an issue particularly in clinical settings, where a high level of anxiety can result in decreased learning,[32] as the participants in this study were not familiar with the Octave and the experience made them feel more confident following the training. This is concurrent with the findings from the verbatim comments, which revealed that students found the Octave helpful for "gaining confidence."

Similar findings from the nonparametric testing gain scores revealed the ability to initiate CPR, perform bag mask ventilation, and follow BLS guidelines as the measures that showed statistically significant gain in confidence with the nonimmersive environment showing the greatest gain. Similar findings in two of the measures (initiating CPR and performing bag valve ventilation) revealed that the Octave was more successful in participants' confidence gain than the immersive suite. Again, the Octave adds the enhanced technology, which makes participants feel more confident, yet the nonimmersive environment is a clear winning environment. This is understood to be due to the familiar surroundings, which does not put any pressure on the students; they feel comfortable in the nonimmersive environment. In contrast, in the unfamiliar environment (Octave), participants reported feeling "overwhelmed as a result of the new environment." In preparation for clinical practice, perhaps this is a very useful experience, as in a real-life emergency such as a cardiac arrest, it is normal to feel overwhelmed.

Participants in this area also reported that they "needed time to adjust." Realistically, cardiac arrests can happen anywhere and in a variety of different circumstances; it is not possible to prepare and have time to adjust in clinical practice, again proving the benefit of the Octave as an unfamiliar environment. One of the participants made the crucial comment that they felt "the unfamiliar environment (Octave) helped them to develop emotional intelligence to deal with emergency situations." Indeed, the development of emotional intelligence is crucial in preparing nurses to be able to deal with acute care situations and is referred to by Cleary et al[33] as an important element of success in an emergency situation that requires recall of the BLS training that you have had in the past during a cardiac arrest.

It is perhaps the case that the fear of the unknown has a dramatic effect on the confidence and skills of those involved in this study. Importantly, as nurses, we can never be certain what will greet us during the shift; nurses need to be knowledgeable and possess the correct skills set to deal with the patient requirements, and they need the emotional resilience to be able to adapt to often rapidly changing circumstances and be able to deal with external stressors.[33] The psychological fear of change (metathesiophobia), or "elephant in the room," can present a significant barrier to learning, but as demonstrated, this could be useful in the preparation of student nurses who are constantly challenged with different situations.

It is fair to say that the levels of immersion had a significant impact during the study. The realism that the higher levels of fidelity offer is certainly more conducive to building confidence in some areas. In support of these findings, an international study carried out in America and Sweden by Creutzfeldt et al[12] identified that an important aspect is the degree of realism and the sense of presence in virtual world training. They suggest that there is a risk that participants may perceive the training environment as "awkward" and that they may experience a lack of real-world resemblance. Our study presented a comparison of more realistic challenging learning environments alongside a familiar learning environment. The benefit of the more challenging environment is that it enables the nurses to increase their confidence and skills in a more realistic environment, through repeated exposure; it presents a realistic overview of the realistic confidence and skills ability when faced with a cardiac arrest in real life. Pushing the boundaries of traditional BLS training environments may present a truer picture of their competence and confidence, and alternating training areas for BLS to prevent students becoming "comfortable" in their learning environment may strengthen their ability to cope with emergency situations wherever they occur.

Similarly, in situ simulation allows learners to adapt and utilize the skills and underpinning framework that have been learnt in a variety of settings and circumstances. Walker et al[34] described a British study whereby in situ simulation was found to be beneficial particularly for staff who had less exposure to cardiac arrests. They advocate the use of this method of simulation as part of patient safety initiatives, having identified a number of issues that, had they occurred during a real resuscitation attempt, might have led to patient harm or patient death. For these reasons, they felt that in situ simulation should be considered by every hospital as part of a patient safety initiative. Clearly, this level of simulation has its uses and undeniable benefits, yet the obvious barriers to its widespread use would include time, resources, and space. As Lighthall et al[35] reminds us, in situ simulation is more useful in understanding how healthcare providers and their environment function during a cardiac arrest situation, proving to be good preparation for the real event.

Nevertheless, for the purpose of educating student nurses, it would be more suitable to utilize simulation out of the clinical environment due to the student numbers, and immersive and VR technologies are important educational facilities that will enable the learners to develop the required skills and confidence in a safe environment without any risk to patients. Verbatim comments supportive of this, such as, "placing students in an environment as realistic as possible may help to develop emotional intelligence, physical, and clinical qualities required to deal with emergency situations," shows an understanding of the significance of having a realistic learning environment to assist in developing the necessary skills.

CONCLUSION

This study examined and compared the effect that a more challenging, unfamiliar novel learning environment has on BLS-associated skills and learner confidence levels, as opposed to more familiar learning environments.

New challenges in nurse education have encouraged nurse educators to seek alternative educational modalities such as simulation, including VR. These methods allow the development of crucial skills, including communication and critical thinking. The use of VR and immersive technologies tests the confidence and the ability of the students.

The difference in utilizing unfamiliar as well as familiar environments should be considered, and educators should appreciate the value of using familiar environments to build the initial skills required but then pushing the boundaries by placing students in unfamiliar and uncomfortable educational settings, to be able to increase their confidence and ability to cope in emergency situations. Immersing students in an HFS experience allows students to further use their team skills as, in reality, there is often more than one rescuer present,[12] and a lack of team coordination could hamper the effectiveness of BLS. A future study will explore the use of the variety of simulated environments and the effect on the development of team working skills.

The added educational benefits of VR and immersive simulation are clearly useful overall and particularly align to the ancient Chinese philosopher, Confucius, who claimed in 450 BC, "Tell me, and I will forget. Show me, and I may remember. Involve me and I will understand."

RECOMMENDATIONS FOR FUTURE STUDIES

The recommendations following the study are that educators should alternate BLS training environments to prevent students becoming "comfortable in their surroundings," strengthening their ability to cope with emergency situations wherever they occur. There should be repeated exposure to more realistic situations to demonstrate the increase in confidence in preparation for the real-life situation.

Although this study has focused on the education of nurses, the findings can be useful for other disciplines that required BLS training. The findings are transferable across multiple disciplines and of international significance, due to the potential impact on the skills and the confidence required to perform BLS.

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