Abstract

Background: Physical assessment is foundational to the nursing process. Knowledge of physical assessment is critical in nursing practice.

Sample: Undergraduate nursing students

Method: This quasi-experimental study integrated augmented reality (AR) to assist nursing students to learn techniques of heart/lung assessment. A treatment group using AR technology viewed an overlay of the heart, lungs and rib cage to enhance understanding of correct placement for assessment techniques using anatomical landmarks for respiratory/cardiac assessment compared to a control group without AR.

Results: Learning outcomes and learner satisfaction were compared. Psychomotor scores demonstrated an advantage to the AR group. Based on the comparisons between the AR group and the control group, our results demonstrated that the use of AR has the potential to improve the performance and content-mastery in nursing students.

Conclusion: AR is a valuable tool for nursing students to apply concepts of physical assessment.

Keywords: Augmented reality; AR; education; nursing; simulation; hologram

Background

Accurate physical skills are foundational for safe patient care. There are various teaching strategies employed to teach these specific skills in pre-licensure programs include: assessment of peers or standardized patients, the use of low and high-fidelity simulators, and computer-based virtual simulations (Jeffries, 2020). Recommendations have been suggested to improve nursing physical assessment education in core skills using alternative teaching approaches (Tan et al., 2021). The purpose of this pilot study was to examine the effects of using augmented reality (AR) in nursing education by comparing the performance of physical assessment skills of heart, lung, and thorax assessment by nursing students who used AR with students who only participated in non-AR experiences.

Key Points

1. Conducted pilot study to determine the feasibility and acceptability of using AR in nursing education.
2. Evaluated performance of AR group in comparison with control group in the pilot study.

Understanding anatomical landmarks are essential for accurate placement of the stethoscope for auscultation. Lack of confidence and knowledge in performing chest auscultation during physical assessment was a perceived barrier for rarely completing the patient skill (Alamri & Almazan, 2018; Birks et al., 2014). It was hypothesized that integrating augmented reality (AR) simulation into the nursing curriculum will improve education of physical examination by bridging theory to practice.

Sample

The population was a convenience sample of first semester sophomore-level undergraduate nursing students enrolled in the traditional Bachelor of Science Nursing (BSN) 16-week physical assessment course during fall 2020. Following IRB review, students were approached during the face-to-face lab portion of the course explaining the study, risks, benefits, and inviting them to participate.

Seventeen students participated in the study and were divided into a control group and an experimental group. Seven were part of the control group and ten participated in the AR experience. Both groups were provided the same information about the study by one of the co-investigators at the beginning of their scheduled lab session. Consents were previously available to students and were reviewed by co-investigator, answered any student questions, and collected the signed consents, which also addressed the potential risks. Both groups were given five minutes to review the rubric and practice on manikins. Students in the intervention group were able to use the AR device during practice.

Method

The goal for this project was to design an AR simulation to complement existing content in the nursing physical assessment course and improve both psychomotor skill and clinical competence. Using AR headsets, the application allows the user to overlay 3D models of animated human organs on manikins. The visualized organs are those relevant to cardiopulmonary assessment.

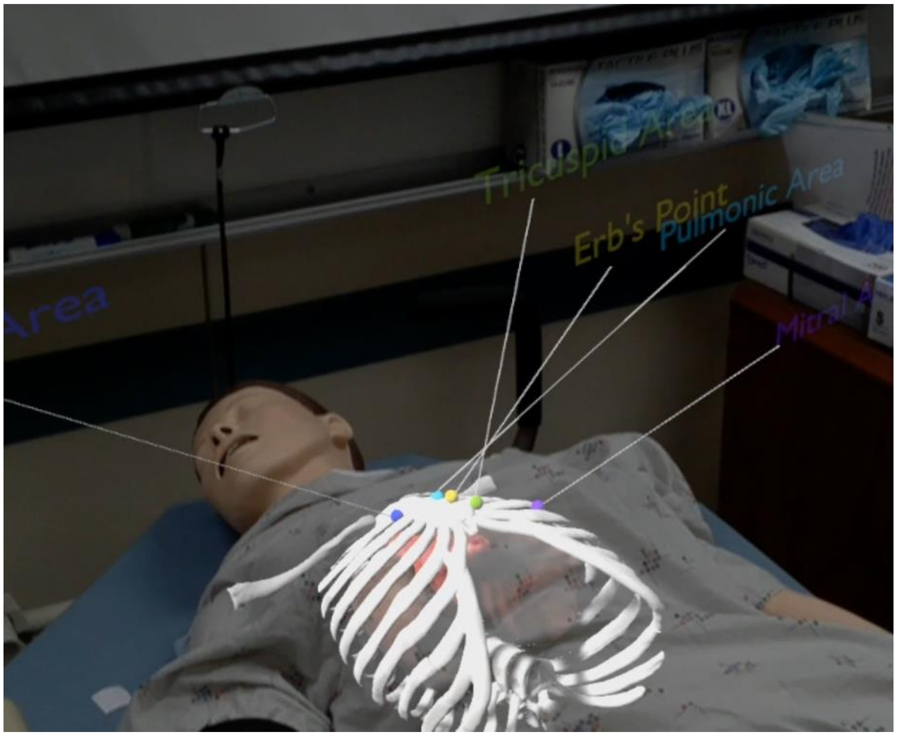

Figure 1: Hologram Overlay on Manikin

System Design

The application uses 3D models of ribs, heart, lungs, and also contained a “guide” button that showed the accurate auscultation site locations for stethoscope placement. Animations were added to the heart and lung models so students could visualize these organs accurately. Five variations of lung sounds had also been made available for different training scenarios, which included bronchial, vesicular, bronchovesicular, and wheezing sounds. Heart sounds included S1 and S2.

Operation

This application allowed students to visualize internal organs functioning accurately during assessment using the Magic Leap One AR headsets. The AR headsets used a customdesigned QR marker placed on the manikin for hologram placement. Vuforia SDK was used for marker detection. Students could remove holograms of selected organs using the controller.

Instrumentation

Demographics were collected using a short questionnaire. The NLN Student Satisfaction and Self-Confidence in Learning (National League for Nursing, 2005) was used to measure response to the simulation and perceived learning. The survey consists of a 13-item instrument designed to measure student satisfaction (five items) with the simulation and self-confidence in learning (eight items) using a five-point Likert scale. Reliability was tested using Cronbach's alpha: satisfaction = 0.94; self-confidence = 0.87. A researcher-developed rubric was used to measure students' physical assessment performance based. The rubric focused on thoracic assessment including inspection, palpation, auscultation of cardiac and pulmonary structures. Students were assessed using a rubric adapted from Physical Examination & Health Assessment (8th ed.) by Jarvis and Eckhardt (2020). The rubric entitled Heart, Lung & Thorax Assessment Rubric was reviewed by seven experts who have experience in teaching physical assessment skills to undergraduate nursing students. Changes were made to the rubric according to feedback received from the experts.

Both the intervention and control groups were given an opportunity to review the rubric, which was taken from the two sections of the final head-to-toe physical exam competency rubric. The AR device focused on accurate placement for inspection and auscultation. The parameters in the assessment rubric that corresponded to the functionalities implemented in the AR application were pulmonary assessments of bronchial, vesicular, and bronchovesicular auscultation, and the cardiac assessments of aortic, pulmonic, mitral, and tricuspid valves auscultation. The parameters present in the rubric that were not available in the AR implementation are skin color, thoracic symmetry, ease of respiration, lump masses, adventitious breath sounds, heave/thrill, extra heart sounds, apical rate, and apical position.

Procedures

Following randomization, all students participated in traditional didactic instruction. Observation 1: Students practiced their assessment skills on a manikin. The AR group had enhanced practice using the thoracic simulation. The control group practiced on the manikin without AR. Following practice, student performances were assessed using a rubric to measure psychomotor skills of heart and lung assessment. Both groups then completed the demographic questionnaire and the NLN Student Satisfaction instrument. Observation 2: After two-four weeks, all students completed an end of the semester final head-to-toe physical examination competency, scores on the heart and lung assessment portion provided data for comparison of groups. Scores earned on the practice sessions were not factored into students' final grades, only used for comparison to the final head-to-toe competency.

Results

Mean and standard deviations were calculated for the control and the experimental groups for both Observations 1 and 2. To determine the statistical significance of using AR, two-tailed, unpaired t-tests were performed on the control and experimental group datasets. Two-tailed, non-parametric Wilcoxon test was also performed resulting in no change in the statistical significance of parameters. Cohen's D was used to determine the effect size on these datasets. These tests were performed separately for both observations. In order to ensure confidence in the statistical analysis of our data, we opted to perform a variety of measures. Since t-tests are one of the standard tools for comparative analysis of two separate measures, it was included in our data analysis. An alternative approach to the t-test, the Wilcoxon test, was also used to ensure there was agreement between those two tests. In addition, Cohen's D was computed as a measure for how much of an effect the AR had on the student's learning experience. Lastly, a power analysis was performed to determine whether the number of participants was already sufficient for statistical significance or - if not – how many participants were needed. Cohen's D was interpreted as follows: $d < 0.2$ (small effect), $0.2 < d < 0.79$ (medium effect), and $d > 0.8$ (large effect size). Finally, a power analysis was performed to identify the number of candidates required to observe statistical significance for each questionnaire parameter.

Table 1

Observation 1: Control group vs. AR group

Measure	Large Effect						Medium Effect
	Ausc. BronchoVesicular	Vesicular	Aortic Valve	Pulmonic Valve	Tricuspid Valve	Mitral Valve	Ausc. Bronchial
Mean Control	0.7142857	0.4285714	0.4285714	0.7142857	0.4285714	0.5714286	0.8571429
Mean AR	1	1	1	1	0.9	1	1
Standard Deviation Control	0.48795	0.5345225	0.5345225	0.48795	0.5345225	0.5345225	0.3779645
Standard Deviation AR	0	0	0	0	0.3162278	0	0
Cohen's D - D Estimate	0.9858201	1.690309	1.690309	0.9858201	1.129237	1.267731	0.5976143
t-test - p (probability of failure of null hypothesis)	0.05986	0.003722	0.003722	0.05986	0.03683	0.02123	0.244
Power Analysis (Ideal Number of Participants)	17.32307	6.607778	6.607778	17.32307	13.34233	10.81753	44.93449

Table 1 shows the results obtained in Observation 1 organized by effect sizes which demonstrated high statistical significance during Observation 1. The AR group achieved higher scores in examining differences between the two groups on individual components of the assessment rubric that corresponded to the functionalities present in the AR application. The AR group also demonstrated to have a large effect with thoracic symmetry (d=0.86) and apical rate (d=0.92). Small to negligible effects were observed in assessments of skin color, lump masses, heave thrill, and apical position. Adventitious breath sounds, ease of respiration, and bronchial sounds demonstrated medium effect sizes.

Table 2

Observation 2: Control group vs AR group

Measure	Medium Effect	Small Effect	Negligible Effect				
	Vesicular	Pulmonic Valve	Tricuspid Valve	Mitral Valve	Ausc. Bronchial	Ausc. BronchoVesicular	Aortic Valve
Mean Control	0.8571429	1	1	1	1	1	1
Mean AR	1	0.9	1	1	1	1	1
Standard Deviation Control	0.3779645	0	0	0	0	0	0
Standard Deviation AR	0	0.3162278	0	0	0	0	0
Cohen's D - D Estimate	0.5976143	0.4082483	0	0	0	0	0
t-test - p (probability of failure of null hypothesis)	0.244	0.4204	1	1	1	1	1
Power Analysis (Ideal Number of Participants)	44.93449	95.1563	N/A	N/A	N/A	N/A	N/A

Observation 2 was performed at the end of the semester after students had the chance to practice and study for their examinations. No additional AR experiences were provided. As shown in Table 2, the results of the analysis of Observation 2 demonstrated that given the small sample size none of the parameters showed statistically significant according to the performed t-test. The AR group showed no significant improvement with respect to the parameters that already were statistically significant and had large effect sizes. Skin color, ease of respiration and lump masses showed negligible effect sizes.

Comparing Observations 1 and 2, the control group demonstrated improvements in statistical significance and large effect sizes for these parameters, whereas the same comparison for the AR group yielded mostly unchanged values between the two observations.

The satisfaction reported by the students following the NLN guidelines was marginally higher for students that used the AR for training at 4.6 whereas students in the control group reported 4.4. These were provided on a Likert scale ranging from 1 through 5. The reported confidence among both groups was similar at about 4.5.

Pilot Feasibility

As a pilot, the authors were able to identify several areas to improve the study: 1) The rubric will be revised to increase the sensitivity of observations. For example, more granular criteria for some data collection, such as auscultation of heart sounds, may help with the interpretability of the resulting data. Currently, if the rubric indicates correct placement, revision will include criteria of the use of anatomic landmarks to assure correct placement, 2) additional faculty training in the use the AR equipment, 3) establish interrater reliability of the rubric, 4) results indicated that we need a larger sample size of 35-45 participants to detect statistical significance for several of the observed measures. Next steps are to conduct the study with a larger sample size. Revisions include making improvements to rubric and establishing interrater reliability, improve training of faculty with AR.

Conclusion

This was a pilot study and thus the sample size was small. More extensive research is required in the future to confirm the validity of using AR in nursing education. Comparing the participants of the control and AR groups in Observation 1, the use of AR demonstrated significant improvement in the AR group regarding auscultations of bronchovesicular, vesicular, aortic, pulmonic, tricuspid, and mitral valves. The areas of improvement were those reinforced by the AR simulation, such as correct auscultation placement. Practicing with the AR overlay of heart and lung structures along with the auditory prompts improved student performance initially.

Observation 2, the analysis revealed large improvements in the control group with these parameters after studying. There were no statistical or clinical differences noted between the groups, albeit the AR group performed marginally better. During the time period following initial training the control group was able to develop similar level of skill as the AR group. This supports the theory that digital simulations accelerate learning in participants and improve memory retention (Smith et al., 2016). This finding is corroborated by a study conducted by Hou et al. (2013), wherein AR was demonstrated to be more effective in terms of faster learning and enhanced performance when compared to non-AR participants, regardless of the participants' gender.

Between Observation 1 and 2, the AR group showed no statistically significant improvements after studying as they were already on a high level. Small improvements were observed in the AR group for auscultations of tricuspid and pulmonic valves after studying. It is important to note that the AR was experienced one time. Future studies are needed to examine effects of the frequency of AR experiences, in addition to long term retention of content. Results of this pilot study supported the value of this technology for nursing students. The authors will use increased sample sizes for the next study. This study suggests that AR is a valuable teaching tool with applications in many areas of nursing.

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