Effect of Using Virtual Reality Simulation versus Instructor-Led Demonstration on Nursing Students' Clinical Performance and Self-efficacy

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***Abstract**:*

Background: *Virtual reality simulation is a valuable tool in critical care nursing education and can provide an avenue for identifying weaknesses both in individual student performance and in program content. It provides a controlled environment that imitates a real-life patient care setting and allows students to learn, practice, and repeat procedures as often as necessary in order to correct mistakes, master skills, and optimize clinical outcomes.* ***Aim****: to determine the effect of using virtual reality simulation versus instructor-led demonstration on nursing students' clinical performance and self-efficacy.* ***Setting:*** *A quasi-experimental, time series posttest design was conducted at the information technology and skill laboratories at Faculty of Nursing, Damanhour University and at the General ICU of Damanhour Chest Hospital.* ***Subjects:*** *comprised of 80 students enrolled in the Critical Care Nursing (I) course and were selected randomly and divided into control and study groups.* ***Tools:*** *Three tools were used. Tool one: "Central Venous Pressure Measurement Check list". Tool two: "Students' Self-efficacy Scale of Central Venous Pressure Measurement". Tool three: "Students' Feedback Questionnaire on Virtual Reality Simulation".* ***Results:*** *revealed that the students in* ***v****irtual reality simulation group performed better in total CVP measurement than students in the instructor-led demonstration group when they encountered real patients in the fifth week of their clinical rotation as well as, in the follow up in the tenth week of their clinical rotation. The same picture was reflected in students' self-efficacy, where the mean percent score of self-efficacy in the VRS group was higher throughout the study phases than in the I-LD group with the exception of the fifth week of their clinical rotation, when they were nearly equal. Furthermore, the VRS program had a larger effect size than the I-LD in terms of improving students' self-efficacy and clinical performance in measuring central venous pressure.* ***Conclusion:*** *The two methods were found to be effective in learning the CVP measurement procedure. The students reported significant benefits from the VRS program as, it was a very interesting, appealing, and effective program for learning the CVP measurement procedure. It provided them with immediate feedback, enhancing their confidence in performing CVP measurements and assisting them in mastering the skill of measuring CVP.* ***Recommendation:*** *Educational workshops should be conducted for all clinical nurse educators about virtual reality simulation strategy to increase their competencies in applying it, and integrating VRS in clinical learning for critical care nursing students to improve their competencies before their first exposure to patients.*

Keywords: Virtual Reality Simulation, Instructor-Led Demonstration, Clinical performance, Self-efficacy.

Introduction

Virtual reality simulation (VRS) has emerged as a valuable supplement to instructor- led demonstration and is thought to be beneficial to nursing students (Badowski et al., 2021). Virtual reality simulation is defined as a combination of computer hardware architecture and software programming that is designed to immerse users in artificially-created virtual environments in which users perceive themselves to be included and interacting in real-time with the environment and its contents (Calabrò & Naro, 2019).

There are four key elements of VRS: the artificial world, immersion, sensory feedback, and interactivity. The artificial world is a three-dimensional (3-D) computer-generated virtual environment that displays descriptions of objects within the simulation as well as the rules and relationships that govern these objects. Regarding immersion, there are two types: physical immersion (sensory) and mental immersion (presence). Physical immersion refers to a system's ability to display an artificially generated environment in a way that it simulates the real experience. Real-time interaction, stereo vision, high frame rate and resolution and multiple displays (visual, auditory, and haptic) are some features that enhance physical immersion. Mental immersion (presence) is defined as a state of being deeply engaged "being there". Regarding sensory feedback, the virtual reality system provides users with direct sensory feedback (most feedback is provided via visual information). Concerning interactivity, it is defined as the user's ability to move within the virtual world and interact with its virtual objects. Virtual characters and objects in the virtual world must respond to and interact with the actions of the user (Izard et al., 2018; Liou & Chang, 2018; Sherman & Craig, 2018).

The degree of immersion in the virtual reality simulation depends on the type of the system used. There are three virtual reality simulation systems: non-immersive, immersive, or semi-immersive virtual reality simulation systems. Non–immersive systems (desktop computer systems) are the most basic, low-cost and widely used type of virtual reality applications. This technique provides a computer-generated environment while allowing the users to remain aware of their physical surroundings. A video game is an excellent example of a non-immersive VR experience (Wohlgenannt et al., 2019; Jung & Park, 2022). Virtual reality like any other technology has some drawbacks. The costs of purchasing equipment, software, maintenance, teacher training, and the need for physical lab space are barriers to using VRS technology in education (Raja & Priya, 2021).

Self-efficacy and clinical performance in nursing education have been linked to virtual reality simulation. Self-efficacy is an individual's belief in their capacity to act in the ways required to achieve specific goals. If students believe in their capabilities, they would use their maximal efforts in different situations. Students with high self-efficacy recover from failure faster and are more likely to attribute failure to a lack of effort. (Bhati & Sethy, 2022). Clinical performance is the student's ability to perform a task and achieve a desirable outcome under certain circumstances within a clinical context. Students perform more confidently in the clinical setting when they are exposed to learning experiences with realistic simulation scenarios. Virtual reality simulation plays an important role in improving student's performance as it promotes trial and error, trains nursing students without putting patients at risk, provides a means of communication, and provides equal access to data (Martín-Gutiérrez et al., 2017; Ying et al., 2017).

There is still a knowledge gap regarding the effect of VRS on both nursing students' self-efficacy and clinical performance. Also, there is an additional

need to conduct studies aimed at assessing whether virtual reality simulation is superior or, at the minimum, comparable to the traditional instructor-led demonstration.

Aim of the study

This study aimed to determine the effect of using virtual reality simulation versus instructor-led demonstration on nursing students' clinical performance and self-efficacy.

Research hypotheses

The following hypotheses were developed:

H1: Nursing students who are trained by virtual reality simulation exhibit higher performance score in central venous pressure measurement than those who are trained by instructor-led demonstration.
H2: Nursing students who are trained by virtual reality simulation exhibit higher self-efficacy in performing central venous pressure measurement than those who are trained by instructor-led demonstration.

Materials and method

Materials

Design: A quasi- experimental, time series posttest design was utilized in this study.

Settings: This study was carried out at the information technology and skill laboratories at Faculty of Nursing, Damanhour University and at the General ICU of Damanhour Chest Hospital.

Subjects: The population targeted for this study was the students in the skill laboratory, which totaled 160 students. The sample size was calculated using the Epi info7 program based on the following information:

- Population size: 160 students
- Expected frequency: 50%
- Acceptable error: 10%
- Confidence coefficient: 97%

The sample size was determined to be 68 students based on the calculations. Therefore, eighty (80) students were invited to participate in this study.

Tools: Three tools were used for data collection in this study.

Tool I: Central Venous Pressure Measurement Check list.

This tool was developed by the Critical Care and Emergency Nursing Department staff at the Faculty of Nursing, Damanhour University to assess the students' clinical performance in measuring the central venous pressure. It was adapted by the researcher as some data were added to help the researcher track the student such as: code no, age, sex, date and unit. The scores were also redistributed for each step of the procedure based on its importance. It was composed of 43 items, 16 items (before the procedure). There were 17 items for during the procedure, covering procedural steps. Moreover, this tool includes 10 items for after the procedure including: post-procedure care for the patient, equipment, environment, and oneself, as well as documenting and reporting unexpected outcomes. Responses to each item were as follows: Done correctly =2, Done incorrectly=1 and Not Done =0 giving a total score ranged from 0-86. The total percent scores were distributed as followed: Poor (< 50%); Fair (50% - <75%); Good (≥ 75%).

Tool II: Students' Self-efficacy Scale of Central Venous Pressure Measurement

This tool was developed by the researcher after review of the literature (Sachitra and Bandara 2017, Kim 2018, Muller and Seufert 2018 and Shin 2018). It was developed to assess students' self-efficacy in performing CVP measurement. It is made up of 20 statements graded on a four-point Likert scale. Five of these were about the person's perception of his/her ability to utilize the CVP measurement equipment appropriately. Three of the statements concerned the person's perception about his/her ability to perform CVP measurement on patients

whose nursing care is complicated. Six statements concerned the person's perception of his/her ability to correctly perform and interpret all the procedural steps, as well as deal with any problems that developed during the procedure. Furthermore, six statements concerned the person's perception of his/her ability to monitor his/her practical performance, as well as make the right decision to report any mistake and solve any problem. Responses to each item ranged from strongly disagree= 1 to strongly agree= 4 giving a total score ranged from 20-80. The total score was converted to percent score and distributed as followed: Low self-efficacy (< 50%); Moderate self-efficacy (50% - <75%); High self-efficacy (≥ 75%).

Tool III: Students' Feedback Questionnaire on Virtual Reality Simulation

This tool was developed by the researcher after review of the literature (Verkuy and Mastrilli 2017, Eyikara and Baykara 2017, Nissim and Weissbluth 2017 and Henderson. etal. 2019) to obtain students' opinions and feedback on the utilization of virtual reality simulation. The questionnaire included 26 closed-ended questions on a four-point Likert scale. There were 16 questions about the advantages of VRS program. These questions include the advantages of the virtual reality simulation program on various learning domains (cognitive, psychomotor, and affective domains). There were 10 questions about the disadvantages of VRS program. These questions include the disadvantages of VRS program's physical and psychological health risks. Moreover, questions regarding the VRS program's requirements, such as (specific environmental preparation and specific training). There were also questions about the program's credibility and interaction. Responses to each item ranged from strongly disagree= 1 to strongly agree= 4 giving a total score ranged from 26-104. The total score was converted to percent score and distributed as followed: Low (< 50%); Moderate (50% - <75%); High (≥ 75%).

Method

Approval from the ethical committee in the Faculty of Nursing, Alexandria University was obtained. Permission to conduct the study was obtained from the Dean and the head of the Critical Care and Emergency Nursing Department at the Faculty of Nursing, Damanhour University. Permission to conduct the study was obtained from the administrative authority of the Damanhour Chest Hospital. Tool I was adapted by the researcher. Tools II and III were developed by the researcher after extensive review of the related literature. The tools were tested for their content validity by five experts in the nursing education, and then the necessary modifications were made. Moreover, the study tools were tested for reliability using Cronbach's Alpha test. The tools were reliable and their coefficient values were 0.893, 0.805 and 0.713 for tool I, II and III respectively. A pilot study was carried out on 8 students to test the clarity and applicability of the tools and they were excluded from the sample. The necessary modifications were done accordingly.

Data collection phases:

Data collection was carried out through three phases.

I- Preparation phase: There were two steps in the preparation phase: step one: designing Virtual Reality Simulation software. A graphic designer and simulation modeling developer was assisted in the construction of the VRS software in collaboration with the E-learning Center at Alexandria University.

Step two: the researcher received training on the utilization of VRS Software program at Alexandria University's E-learning center. Also, the researcher trained two teaching staff members to assist in the instructor-led demonstration and the evaluation of students in both groups.

2- Implementation Phase: Training in the laboratories (skill or information technology laboratory).

For control (I-LD) group: First week: (Monday and Tuesday groups) from 8:30 a.m. to 10:30 a.m.: two trained teaching staff used the instructor-led demonstration method to train students in the control group on central venous pressure measurement procedure in the skill laboratory. The demonstration was carried out with the help of a simulator known as the Chester Chest TM Model 2400 with New Advanced Arm. They took a break from 10:30 a.m.to11:00a.m then they were asked to complete the students' self-efficacy scale of central venous pressure measurement from 11:00 a.m. to 11.30 a.m. From 11.30 a.m. to 1.30 p.m., students were left to re-demonstrate under the supervision of the two trained teaching staff. From 1.30 p.m. to 2.00 p.m. The students were asked to complete the self-efficacy scale of central venous pressure measurement again. Fourth week: This was an open laboratory for students to practice the CVP procedure. The Instructor-Led Demonstration group had practiced the central venous pressure measurement procedure in the skill laboratory under the supervision of two teaching staff.

For study (VRS) group: First week: (Monday and Tuesday groups) from 8:30 a.m. to 10:30 a.m.: The students in the study group were instructed to use headphones to listen and observe the central venous pressure measurement procedure on the designed virtual simulation software and to repeat it as needed under the supervision of the researcher in the information technology laboratory. They took a break from 10:30 a.m. to 11:00 a.m. then, they were asked to complete the self-efficacy scale of central venous pressure measurement from 11:00 a.m. to 11.30 a.m. From 11.30 a.m. to 1.30 p.m., students were left to practice the procedure on the screen and interact with the designed software. From 1.30 p.m. to 2.00 p.m., after practicing the procedure the students were asked to complete the self-efficacy scale of central venous pressure measurement again. Fourth week: This was an open laboratory for students to practice the central venous pressure measurement procedure. The VRS group had practiced the CVP procedure in the IT laboratory under the supervision of the researcher.

3- Evaluation Phase: Students' evaluation was done by the researcher and two trained teaching staff on the fifth and the tenth week of the clinical rotation. Fifth week: Firstly, the students in both groups were asked to complete the self-efficacy scale of central venous pressure measurement before measuring central venous pressure on actual patients. Secondly, the students were evaluated by the researcher and the two trained teaching staff on measuring central venous pressure on actual patients using the central venous pressure measurement checklist. Tenth week: Firstly, the students in both groups were evaluated by the researcher and two trained teaching staff on the central venous pressure measurement on actual patients using the central venous pressure measurement checklist. Secondly, the students in both groups were asked to complete the self-efficacy scale of CVP measurement. Thirdly, the students' feedback questionnaire on virtual reality simulation was given to the VRS group only to assess their feedback on the VRS program.

Ethical considerations

A written informed consent was obtained from every nursing student after the explanation of the study's purpose and reassurance about the privacy and confidentiality of the data was done. It was announced that participation is on voluntary basis and students had the right to withdraw from the study at any time without any drawbacks.

Statistical Analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean

and standard deviation. Significance of the obtained results was judged at the 5% level (p-values of ≤ 0.05). Chi-square was used for test of significance with P values.

Results

Table I displays the comparison between virtual reality simulation and instructor-led demonstration groups according to personal characteristics. Concerning the students' age, 82.5% of the VRS group compared to 72.5% of the I-LD group aged between 20 to less than 21 years. Moreover, 17.5% of the VRS group compared to 25.0%of the I-LD group aged from 21 to 22 years. Regarding the students' sex, three quarters of the VRS group were females, whereas, 60.0% of the I-LD group were males, with a statistically significant difference between both groups (P= 0.002).

Table II illustrates the comparison between VRS and I-LD groups according to self-efficacy levels and mean scores throughout the study phases. In relation to the VRS group, 37.5% of the students had a high self-efficacy level immediately after intervention which increased to 67.5% after practicing the CVP procedure and decreased in the fifth week and the tenth week of the clinical rotation to 65.0% and 55.0% respectively with a statistically significant difference between the study phases (p= 0.031). The table also portrayed the same picture in the mean percent score of self–efficacy as it was 69.72% immediately after the intervention and increased to 84.12% after practicing the CVP procedure and decreased in the fifth week and the tenth week of the clinical rotation to 81.54% and 80.35% respectively with a statistically significant difference (p=0.009). Regarding the I-LD group, it can be noted from the same table that 25.0% of the students had a high self-efficacy level immediately after intervention which increased after practicing the CVP procedure and on the fifth week of the clinical rotation to 37.5% and 45.0% respectively. In the tenth week of the clinical rotation, it had dropped to 25.0%. Moreover, the table shows the same change in the mean percent score of self-efficacy as it was 65.38% immediately after the intervention and increased to 79.5% and 81.25% respectively after practicing the CVP procedure and in the fifth week of the clinical rotation. The mean percent score of self-efficacy for the I-LD group decreased to75.25% in the tenth week of the clinical rotation with a statistically significant difference (p<0.001).

Table III reveals the comparison between VRS and I-LD groups according to CVP measurement performance levels and mean scores in the 5^{th} and the 10^{th} week of the clinical rotation. In the fifth week of the clinical rotation, 90.0% of the students in VRS group and 80.0% of the students in I-LD group had a good level in total CVP measurement performance which increased to 100.0% of the students in VRS group and 90.0% of the students in I-LD group in the tenth week of the clinical rotation with no statistical significant difference (p = 0.348 and p =0.116 respectively). The table also reveals that in the fifth week of the clinical rotation, the mean score of total CVP measurement performance was 71.88±7.793 for VRS group and 69.00±10.25 for I-LD group with no statistical significant difference (p = 0.161), which increased to 77.85±6.024 for VRS group and 73.82±9.868 for I-LD group in the tenth week of the clinical rotation with a statistical significant difference (p = 0.030).

Discussion

The results of the current study revealed that the students in VRS group performed better in total CVP measurement than students in the instructor- led demonstration I-LD group when they encountered real patients in the fifth week of their clinical rotation as well as, in the follow up in the tenth week of their clinical rotation. Therefore, the first hypothesis "Nursing students who are trained by virtual reality simulation exhibit higher performance score in central venous pressure measurement than those who are trained by instructor-led demonstration" was accepted. The same

picture was reflected in students' self-efficacy, where the mean percent score of self-efficacy in the VRS group was higher throughout the study phases than in the I-LD group with the exception of the fifth week of their clinical rotation, when they were nearly equal. Therefore, the second hypothesis "Nursing students who are trained by virtual reality simulation exhibit higher self-efficacy in performing central venous pressure measurement than those who are trained by instructor-led demonstration" was accepted. These findings, which revealed that the VRS group exceeded those in the I-LD group in terms of clinical performance and self-efficacy, are consistent with the findings of Lee, (2022), who conducted a study to develop VRS for intravenous (IV) injection and examine how it affects nursing students' academic knowledge, performance confidence, and clinical practice competencies. Using a VRS training system for IV injection resulted in significantly higher knowledge, performance confidence, and clinical performance competency when compared to demonstration training using an IV arm simulator. This study confirmed that VRS for IV injection practice was more effective than an IV arm simulator. In addition, Chiang et al., (2022) conducted a study that compared the effectiveness of manikin-based training and VR-based training on the self-efficacy of healthcare providers in tracheostomy care skill. Healthcare providers, including physicians, nurses, and respiratory therapists, were enrolled. The self-efficacy of VR-based trainees was found to be significantly higher than that of manikin-based trainees. In contrast, Jeong et al., (2022) conducted a study to develop and evaluate the effectiveness of a VRS program for nursing students using the COVID-19 scenario. The experimental and control groups were assessed on their knowledge of respiratory infectious diseases, self-efficacy, and learning satisfaction. The lectures were delivered to the control group via the Zoom program in order to reduce the risk of infectious disease spread through gatherings. The VRS program was used on the experimental group. Learning satisfaction was significantly higher in the experimental group. However, there was no difference between the groups in terms of knowledge, or self-efficacy. The finding that there was no difference in knowledge between the groups might be attributed to that medical information on COVID-19 was regularly disseminated through various media over the study's duration. Moreover, there was a prerequisite learning session for both groups. Therefore, the contents of the prior learning session may have offered sufficient information to enhance understanding in both groups. In contrast to the present study, the students had no prior knowledge of central venous pressure measurement. The lack of a statistically significant difference in self-efficacy in nursing care for respiratory infectious disease may be due to COVID-19 and the social distancing policy, as students in the experimental group only experienced the VR simulation once. Furthermore, the posttest was performed immediately following the simulation. Thus, there was a possibility that there was not enough time to enhance self-efficacy for the students. In the current study there was enough time to enhance self-efficacy for the students. Many reasons could explain all previously mentioned results and may clarify why students in the VRS group exceeded those in the I-LD group in terms of clinical performance and self-efficacy. Firstly, the VRS program may encourage students to be active and independent learners, as evidenced by students who reported that VRS increased their willingness to learn actively and assisted them in becoming independent learners. Being an active and independent learner improves self-efficacy which in turn improves clinical performance. According to Henderson et al. (2018), engaging nursing students as active partners in their clinical learning allowed them to develop self-efficacy and enhanced their performance. Secondly, students learned at their own pace and were able to repeat any difficult step of the procedure multiple times, which improved their understanding and confidence in measuring CVP, as students revealed that VRS helped them to learn flexibly at their own pace

and gain more confidence in performing CVP measurement. Al Gharibi et al., (2021) reported that repeated simulation experience was an excellent way for nursing students to retain knowledge and skills while increasing self-efficacy. Thirdly, the activities in the program were designed in an attractive manner that drew their attention and encouraged them to become immersed in order to achieve high scores, as students indicated that VRS helped them maintain their focus on learning CVP measurement without distraction and become more motivated to learn. Kim and Suh (2018) examined the effect of an interactive nursing skills mobile application on nursing students' knowledge, self-efficacy and skills performance. The findings revealed that the students' knowledge, self-efficacy, and nursing skills performance had improved. Finally, students reported that the VRS program assisted them in gaining and retaining more knowledge and skills in measuring CVP. In addition, they reported that the VRS program provided them with immediate feedback on performance and identified their strengths and weaknesses, which assisted them in confirming understanding, clarifying misconceptions, and improving their weaknesses. In a study conducted by Burgess et al., (2020) to explore the role of feedback in the learning process, it was concluded that feedback is an essential element of the learning process, and is considered an important part of the curriculum. Additionally, regular and timely feedback reinforces good practice and motivates the learner to accomplish the desired goal. It can be assumed from the preceding reasons that the VRS program was successful in providing students with necessary knowledge about CVP procedure, developing their self-efficacy and preparing them to interact with patients. Therefore, when students encountered real patients in the fifth week of their clinical rotation, they exceeded the I-LD group. After practicing the CVP measurement on the patients, the students reached the highest level of performance by the tenth week of their clinical rotation. On the other hand, students in the I-LD group had few opportunities to perform or re-demonstrate CVP measurement procedure more than once due to time constraints, despite the fact that most students wanted to repeat the procedure multiple times. Furthermore, the number of students is increasing. It is noticeable that the listed causes were related to a defect in the circumstances surrounding the practical training, rather than to the educational method itself. Therefore, when students encountered real patients in the fifth week of their clinical rotation, they performed slightly lower than the VRS group. The students' performance improved after practicing the CVP measurement on patients by the tenth week of their clinical rotation, but it was still slightly lower than the VRS group.

Conclusion

It can be concluded from the current study that the two methods were found to be effective in learning the CVP measurement procedure. In terms of improving students' self-efficacy and clinical performance in measuring central venous pressure, the VRS program was found to have a larger effect size than the I-LD. Nursing students who were trained by virtual reality simulation had slightly higher self-efficacy and performance scores in CVP measurement than those who were trained by instructor-led demonstration. In the tenth week of the students' clinical rotation, both groups' self-efficacy and performance level in measuring CVP had a positive statistically significant correlation. Furthermore, the students reported significant benefits from the VRS program.

Recommendations

Based on the findings of the present study, the following recommendations are offered:

- Educational workshops should be conducted for all clinical nurse educators about virtual reality simulation strategy to increase their competencies in applying it.
- Nurse educators should use virtual reality simulation learning in combination with traditional clinical learning with critical care nursing students.

- Inclusion of virtual reality simulation method in clinical learning for critical care nursing students to improve their competencies before their first exposure to patients.
- Providing computer courses for nursing students are recommended to enhance their computer skills.

Table (1): Comparison between virtual reality simulation and instructor-led demonstration groups according to personal characteristics

Item	Type of Group				Total n=80		Test of significance
	Study (VRS) (n=40)		Control (I-LD) (n=40)				
	No.	%	No.	%	No.	%	
Age (years)							
- 19-	0	0.0	1	2.5	1	1.2	X^2= 1.787
- 20-	33	82.5	29	72.5	62	77.5	P=0.409
- 21-22	7	17.5	10	25.0	17	21.2	
Sex							
- Male	10	25.0	24	60.0	34	42.5	X^2=10.026
- Female	30	75.0	16	40.0	46	57.5	P=0.002*

X2 Chi square test *: Statistically significant at $p \leq 0.05$
VRS: Virtual Reality Simulation I-LD: Instructor- Led Demonstration

Table (2): Comparison between virtual reality simulation and instructor-led demonstration groups according to self-efficacy levels and mean scores throughout the study phases

Items	Study phases																Test of Significance between study phases	
	Immediately after the intervention				After practicing the CVP procedure				Evaluation on the 5th week				Evaluation on the 10th week				VRS group	I-LD group
	VRS group (n = 40)		I-LD group (n = 40)		VRS group (n = 40)		I-LD group (n = 40)		VRS group (n = 40)		I-LD group (n = 40)		VRS group (n = 40)		I-LD group (n = 40)			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%		
Levels of self-efficacy																		
- Poor	2	5.0	1	2.5	0	0.0	0	0.0	2	5.0	1	2.5	0	0.0	1	2.5	χ^2= 11.975* ^{MC}p = 0.031*	χ^2= 6.593 ^{MC}p = 0.261
- Fair	23	57.5	29	72.5	13	32.5	25	62.5	12	30.0	21	52.5	18	45.0	29	72.5		
- Good	15	37.5	10	25.0	27	67.5	15	37.5	26	65.0	18	45.0	22	55.0	10	25.0		
Test of Significance between groups	χ^2= 2.083 ^{MC}p = 0.413				χ^2= 7.218* p = 0.007*				χ^2= 4.272 ^{MC}p = 0.114				χ^2= 7.961* ^{MC}p = 0.013*					
Mean Score of self-efficacy																		
Mean ± SD	61.83± 6.60		59.23± 6.87		67.30±6.929		63.60±5.874		65.23±7.602		65.00±7.495		64.28±7.432		60.20±7.265		F = 4.008* p = 0.009*	F =6.286* p <0.001*
Min – Max	44.0– 75.0		48.0–79.0		52.0-80.0		53.0-80.0		44.0-76.0		49-80		52.0-80.0		47-80			
Mean Percent Score	69.72%		65.38%		84.12%		79.5%		81.54%		81.25%		80.35%		75.25%			

Test of Significance between groups	t = 1.726 p = 0.088	t = 2.576* p = 0.012*	t = 0.136 p = 0.892	t = 2.483* p = 0.015*		

χ2: Chi square test MC: Monte Carlo
F: F test (ANOVA) with repeated measures for comparing between the four periods
t: Student t-test t: Paired t-test * statistically significant at p ≤ 0.05
Intervention: Instructor-led demonstration for control group and virtual reality simulation for study group
VRS: Virtual Reality Simulation I-LD: Instructor- Led Demonstration

Table (3): Comparison between virtual reality simulation and instructor-led demonstration groups according to total CVP measurement performance levels and mean scores in the 5th and the 10th week of the clinical rotation

Items	**Study Phases**								**Test of Significance between study phases**	
	Evaluation on 5th week				**Evaluation on 10th week**					
	VRS group (n = 40)		**I-LD group (n = 40)**		**VRS group (n = 40)**		**I-LD group (n = 40)**		**VRS group**	**I-LD group**
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**		
Total CVP measurement performance										
- Poor	0	0.0	0	0.0	0	0.0	0	0.0		
- Fair	4	10.0	8	20.0	0	0.0	4	10.0	χ^2= 4.211 FEp =0.116	χ^2= 1.569 FEp = 0.348
- Good	36	90.0	32	80.0	40	100	36	90.0		
Test of Significance between groups	χ^2= 1.569 FEp = 0.348				χ^2= 4.211 FEp =0.116					
Mean Scores of total CVP measurement performance										
Mean ± SD	71.88±7.793		69.00±10.25		77.85±6.024		73.82±9.868		t = 3.833* p <0.001*	t = 2.143* p = 0.035*
Min – Max	50-82		44-84		64-84		46-84			
Mean Percent Score	85.57%		82.14%		92.67%		87.88%			
Test of Significance between groups	t = 1.415 p = 0.161				t = 2.205 p =0.030*					

χ2: Chi square test FE: Fisher Exact t: Paired t-test
t: Student t-test *: Statistically significant at p ≤ 0.05
VRS: Virtual Reality Simulation I-LD: Instructor-Led Demonstration

References

- Al Gharibi, K. A., Schmidt, N., & Arulappan, J. (2021). Effect of repeated simulation experience on perceived self-efficacy among undergraduate nursing students. Nurse Education Today, 106, https://doi.org/10.1016/j.nedt.2021.105057.

- Badowski, D., Rossler, K. L., & Reiland, N. (2021). Exploring student perceptions of virtual simulation versus traditional clinical and manikin-based simulation. Journal of professional nursing, 37(4), 683-689. https://doi.org/10.1016/j.profnurs.2021.05.005.

- Bhati, K., & Sethy, T. (2022). Self-Efficacy: Theory to Educational Practice. The International Journal of Indian Psychology. 10, 1123-1128. 10.25215/1001.112.

- Burgess, A., van Diggele, C., Roberts, C., & Mellis, C. (2020). Feedback in the clinical setting. BMC Med Educ, 20 (Suppl 2), 460. https://doi.org/10.1186/s12909-020-02280-5.

- Calabrò, R. S., & Naro, A. (2019). Understanding Social Cognition Using Virtual Reality: Are We still Nibbling around the Edges? Brain sciences, 10(1), 17. https://doi.org/10.3390/brainsci10010017.

- Chiang, D. H., Huang, C. C., Cheng, S. C., Cheng, J. C., Wu, C. H., Huang, S. S., ….., & Lee, F. Y. (2022). Immersive virtual reality (VR) training increases the self-efficacy of in-hospital healthcare providers and patient families regarding tracheostomy-related knowledge and care skills: A prospective pre-post study. Medicine, 101(2), e28570. https://doi.org/10.1097/MD.0000000000028570.

- Henderson, A., Harrison, P., Rowe, J., Edwards, S., Barnes, M., Henderson, S., & Henderson, A. (2018). Students take the lead for learning in practice: A process for building self-efficacy into undergraduate nursing education. Nurse Education in Practice, 31, 14-19. https://doi.org/10.1016/j.nepr.2018.04.003.

- Izard, S. G., Juanes, J. A., García Peñalvo, F. J., Estella, J. M. G., Ledesma, M. J. S., & Ruisoto, P. (2018). Virtual reality as an educational and training tool for medicine. Journal of medical systems, 42(3), 50. https://doi.org/10.1007/s10916-018-0900-2.

- Jeong, Y., Lee, H., & Han, J.- W. (2022). Development and evaluation of virtual reality simulation education based on coronavirus disease 2019 scenario for nursing students: A pilot study. Nursing Open, 9, 1066– 1076. https://doi.org/10.1002/nop2.1145.

- Jung, A. R., & Park, E. A. (2022). The effectiveness of learning to use HMD-based VR technologies on nursing students: Chemoport Insertion Surgery. International Journal of Environmental Research and Public Health, 19(8), 4823. http://dx.doi.org/10.3390/ijerph19084823.

- Kim, H., & Suh, E. E. (2018). The effects of an interactive nursing skills mobile application on nursing students' knowledge, self-efficacy, and skills performance: a randomized controlled trial, Asian Nursing Research, 12(1), 17-25. https://doi.org/10.1016/j.anr.2018.01.001.

- Lee, J. S. (2022). Implementation and evaluation of a virtual reality simulation: intravenous injection training system. International Journal of Environmental Research and Public Health, 19(9), 5439. MDPI AG. Retrieved from http://dx.doi.org/10.3390/ijerph19095439.

- Liou, W. K., & Chang, C. Y. (2018). Virtual reality classroom applied to science education. In W. K. Liou & C. Y. Chang (Eds.), International Scientific-Professional Conference on Information Technology (IT) (23rd ed p.p. 1-4). IEEE.

- Martín-Gutiérrez, J., Mora, C. E., Añorbe-Díaz, B., & González-Marrero, A. (2017). Virtual technologies trends in education. Eurasia Journal of Mathematics, Science and Technology Education, 13(2), 469-486.

https://doi.org/10.12973/eurasia.2017.00626a.

- Raja, M., & Priya, G. G. (2021). Conceptual Origins, Technological Advancements, and Impacts of Using Virtual Reality Technology in Education. Webology, 18(2), 116-134. https://doi.org/10.14704/WEB/V18I2/WEB18311.

- Sherman, W. R., & Craig, A. B. (2018). Understanding virtual reality: Interface, application, and design. Morgan Kaufmann.

- Wohlgenannt, I., Fromm, J., Stieglitz, S., Radianti, J., & Majchrzak, T. A. (2019). Virtual reality in higher education: Preliminary results from a design-science-research project.

- Ying, L., Jiong, Z., Wei, S., Jingchun, W., & Xiaopeng, G. (2017). VREX: Virtual reality education expansion could help to improve the class experience (VREX platform and community for VR based education). IEEE Frontiers in Education Conference (FIE), 1-5. https://doi.org/10.1109/FIE.2017.8190660.