Effect of Virtual Reality as a Teaching Strategy on Pediatric Nursing Students' Performance Regarding Cardiopulmonary Resuscitation

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Abstract

Background: Virtual reality (VR) is an innovative technology and a computer-generated three-dimensional simulation that is associated with high empirical realism. It provides a vast range of sensory information to the user to interact with objects in a virtual environment and can be used to encourage nursing students develop skills in virtual hospital settings. **Aim of the study** was to evaluate the effect of virtual reality as a teaching strategy on pediatric nursing students' performance regarding cardiopulmonary resuscitation. **Study design:** An experimental design (study & control groups/ pre-posttest) was utilized. **Setting:** The pediatric nursing skills laboratory for third year/ Faculty of Nursing/ Benha University. **Study subjects:** A systematic random sample of (٨٠) pediatric nursing students was selected from the pediatric nursing students who were studying the pediatric nursing course/third year/second semester during the academic year ٢٠٢٢/٢٠٢٣. **Tools of data collection:** Three tools were used; **Tool I:** A structured interviewing questionnaire, **Tool II:** Student's clinical evaluation checklist (pre/posttest) and **Tool III:** Virtual reality–teaching material usability questionnaire (posttest). **Results:** Vast majority of nursing students in study group had good knowledge level post-implementation compared with one third in control group. Also, majority of nursing students in the study group had competent total practices level regarding CPR post-implementation compared with more than half in the control group. Furthermore, vast majority of the nursing students in the study group had positive opinion about virtual reality-teaching material usability post-implementation. **Conclusion:** Virtual reality as a teaching strategy was effective in improving knowledge and enhancing practices of pediatric nursing students regarding CPR. **Recommendations:** Integrating virtual reality technology in nursing clinical courses to reinforce their performance in clinical settings.

Keywords: *Cardiopulmonary Resuscitation, Nursing students, Performance, Teaching Strategy, Virtual Reality.*

Introduction:

Recently, more innovative learning tools have been provided with the development of educational technology. In particular, the field of nursing practice is regarded as a very important process for learners to develop the ability to apply skills and expertise. Therefore, it is very important to identify which learning methods are the most effective for proficiency development to ensure the competence of graduates ***(Ergashevich , ٢٠٢٤).***

Traditional nursing teaching is lecture-centric and instructive. It is largely rely on attendance and memorization. These methods attract obvious limitations. Traditional lectures are boring, monotonous and also had an absence of standardization and factual models which leads to inability of many students to master practical skills completely (***Izard et al., ٢٠١٨ & Kyaw et al., ٢٠١٩).***

Furthermore, among the practical competencies to be acquired, the most difficult to learn are those that are not easy to experience in practice and complicated to perform directly due to certain practical experiences which are essential for the safety of students to compensate for this, efforts have been made to supplement such practice through equipment that incorporates cutting-edge technology, as using virtual reality into nursing education programs ***(Helle & Saljo, ٢٠١٩).***

Virtual reality is a forward-looking innovative simulation technique. It is a computer-created simulation of the real or imaginative environment which displays real time interaction opportunities. Special hardware, like VR glasses and controller, lets the student to experiment surroundings and stances nearly as if being really there. Because of this high standard of immersion, VR is a motivating and favorable modern method of teaching in medical cases, and its application extend rapidly, the learner feels as being a real actor and not like an observer. Every imaginable scenario can be carried out in a virtual world by means of the software, giving the user plentiful possibilities. VR can boost both undergraduate and postgraduate medical education ***(Lessleib et al., ٢٠٢١).***

There are several advantages of utilizing VR. It boosts students' concentration, confidence, motivation, creativity and allows them to put theory into practice. It also provides them with the opportunity to practice whenever and however the

student wants in a realistic environment without fear of making errors and harming pediatric patients. Students taking part in VR simulations are more likely to be comfortable and effective in real clinical setting due to learning in an applied form ***(Gurcan et al., ٢٠١٨ & Nehring et al., ٢٠١٨).***

Traditional CPR training does not permit students to accurately grasp power, depth and frequency. VR helps students to learn CPR, making CPR training more widespread. VR training involves video health education, assisted real-time interactive operation methods and learning tests. Students can practice on their own after watching the training scenario. The system enhances the user's power via a force-sensitive pattern to assure that the students are appropriately trained. It encourages learners to learn CPR skills in an immersive VR environment which direct somatosensory interactions ***(Yang et al., ٢٠٢٠).***

Cardiopulmonary resuscitation training utilizing the VR technology is a convenient and efficient training technique that is highly valued by nursing students**.** VR training could overcome remarkable hindrances for layperson CPR training ***(Jaskiewicz, et al., ٢٠٢٠).*** For improving the quality of training, the optimal combination of chest compression depth and rate in VR resuscitation training is confirmed to be an easily obtainable way to expand CPR skills. Both a simulation system and VR environment could be applied for creating a more realistic training environment for Cardiopulmonary resuscitation ***(Semeraro et al., ٢٠١٩ & Nas et al., ٢٠٢١).***

Significance of the study:

According to the ***Resuscitation Council UK* (٢٠١٥),** it is recommended that CPR training for children should prioritize fulfilling effective compressions and that, feedback and prompts should be combined into training. VR devices assist the incorporation of features of real patients into training to ease interaction and feedback, which in turn promote performance.

Undergraduate pediatric nursing students must be prepared to competently and confidently perform CPR in caring of critically ill children. Students require time and opportunity to practice CPR. Lack of time in the practice lab and/or deficiency of clinical placement experience involving expert feedback on performance may decrease chances for those students to master CPR skills. Nurse educators are challenged to seek out and conduct innovative teaching techniques that provide opportunities for nursing students to practice CPR while maintaining child safety **(*Smith & Hamilton,* ٢٠١٥)**.

In spite of combining virtual reality with training may be a unique and valuable way to reinforce practice of CPR in undergraduate pediatric nursing students, its importance for teaching remains underexplored, however no research about its usability in Egypt, particularly in Benha city exists. Accordingly, the researcher conducts this study to improve pediatric nursing students' performance regarding CPR by utilizing VR and to prepare them to cope in the real emergency situations.

Aim of the Study:

This study aimed to evaluate the effect of virtual reality as a teaching strategy on pediatric nursing students' performance regarding cardiopulmonary resuscitation.

Research Hypotheses:

- Pediatric nursing students who participating in virtual reality training will have higher knowledge scores than the control group.
- Pediatric nursing students who participating in virtual reality training will have higher practices scores than the control group.
- Pediatric nursing students participating in virtual reality training will have positive opinions scores about virtual reality–teaching material usability.

Subjects & Method:

Research Design:

An experimental design (study & control groups/ pretest-posttest) was used. It is a detailed plan for collecting and using data to identify causal relationships

Study Setting:

This study was carried out at the pediatric nursing skills laboratory for third year/ Faculty of Nursing/ Benha University. The laboratory is placed in the fourth floor at the Faculty of Nursing and it contains all the required equipment as (hard surface, doll of CPR (Mega Code Kid A٤٠١١٧ (٤)), ambo bag) for the pediatric clinical procedures except virtual reality equipment.

Study Subjects:

The sample size was calculated using this formula developed by ***(Mason,* ٢٠١٣)** where n is the required sample size, M= total population, S is ١.٩٦ at ٨٠٪ confidence level, the level of error ٥٠٪ (٠.٥٠).The estimated sample size was ٦٠٣ studied nursing students who attending at the previous mentioned setting (The pediatric nursing skills laboratory for third year/ Faculty of Nursing/ Benha University).

n= $\frac{M}{[(S^2 * (M-1)) / P(1-P)] + 1}$

Which:

n= Sample size

M= Total population (٦٠٣)

S= This depends on level of confidence, for ٨٠٪ this is ١.٩٦

P= Error level ٥٪

٦٠٣

———————————————= ٨٠

١.٩٦٢*(٦٠٠-١) / ٠.٥(١-٠.٥) + ١= ٧.٤٩٨

Based on the above formula, the sample size required was ٨٠

Type: A systematic random sample (٨٠) of pediatric nursing students was selected from the pediatric nursing students who were studying the pediatric nursing course/third year/second semester during the academic year ٢٠٢٢/٢٠٢٣.

Technique: The researcher arranged students in some order, picked a random starting point and select every member in a set interval. This interval, called the sampling interval, is calculated by dividing the population size into the desired sample size. In this study the researcher selected pediatric nursing student at fixed intervals of ٨ students. Then, the sample was divided equally into two groups randomly. Group I (study group) composed of ٤٠ pediatric nursing students participating in virtual reality training and group II (control group) included the other ٤٠ pediatric nursing students who trained with the traditional demonstration.

Tools of data collection:

Three tools were used to gather data pertained to the study as the following:

Tool (I): A structured interviewing questionnaire:

It was developed by the researcher after reviewing recent and relevant literatures. It was translated into an Arabic Language and involved two parts:

Part I: Characteristics of the studied students:

It concerned with characteristics of the studied nursing students such as age, gender, residence and attending any CPR training courses using virtual reality (٤ items).

Part II: Students' knowledge assessment questionnaire (pre/ posttest):

It was designed by the researcher based on ***Barfield & Blitz, (٢٠١٩), Kliegman et al., (٢٠٢٠) and Al Nasri & Al Bulushi, (٢٠٢٠)*** to assess pediatric nursing students' knowledge regarding cardiopulmonary resuscitation and virtual reality. It included ٢٦ closed-end questions and composed of the following:

١- **Pediatric nursing students' knowledge regarding CPR** which involved ٢٠ multiple choice questions regarding definition, indication, signs and symptoms, complications, indication of ending CPR, appropriate nursing implementation toward all this (when a child has stopped breathing, when a child's pulse has stopped, to be followed for unconsciousness child, must be followed after making sure that the child does not respond, to be followed after performing CPR, if the child is unconsciousness but breath normally, if the child is not breath normally or no breathing), the landmark for chest compression performed, the method of giving chest compression, the correct rate of pressure on the chest, the ratio of pressure on the chest to the rate of breathing in children when there is only one paramedic, when there is two paramedic, the method of giving breathing, the methods of opening airway and which artery should check the child's plus.

٢- **Pediatric nursing students' knowledge regarding virtual reality**:

It consisted of ٦ multiple choice questions related to definition, indications, types, advantages, disadvantages, applications of virtual reality in pediatric nursing education.

Scoring system for students' knowledge:

A scoring system was estimated in which correct answer was given a score (١), while incorrect answer or don't know was given a score (٠). The total students' knowledge scores were ranged from (٠ - ٢٦) grades which classified into three categories as follows:

- Low level knowledge: < ٦٠٪ (< ١٦ marks) of total knowledge score.
- Average level knowledge: from ٦٠٪ to < ٨٠٪ (from ١٦< ٢١ marks) of total knowledge score.
- Good level knowledge: from ٨٠٪ to ١٠٠٪ (from ٢١-٢٦ marks).

Tool (II): Student's clinical evaluation checklist (pre/ posttest):

It was adopted from ***Lopez-Herce et al., (٢٠١٧)*** to evaluate the pediatric nursing students' practices regarding applying steps of pediatric cardio-pulmonary resuscitation. It included of ٥٠ steps grouped under ٧ domains, as safety (١ step), checking the state of consciousness (١ step), asking for help (٤ steps), child assessment A-B-C opening the airway, checking breathing, checking circulation (١٨ steps), following recommended sequences of CPR (CAB) compression, airway and breathing (١٩ steps), the indication of ending of resuscitation (٤ steps), practices after CPR procedure (٣ steps).

Scoring system of students' practices:

Each done step was given (١) score and (٠) score was given for not done step. The total scores ranged from ٠-٥٠. Accordingly, the total level was categorized:

- Incompetent for less than < ٨٥٪ at total score (<٤٣).
- Competent form ٨٥ to ١٠٠ % at total score (٤٣: ٥٠).

Tool (III): Virtual reality–teaching material usability questionnaire (posttest):

It was adopted from ***Semeraro et al., (٢٠٠٩) & Shibuya et al., (٢٠١٩)*** to evaluate students' opinions about VR usability. It was composed of ٢٧ questions grouped under nine domains, as Understanding (٣ questions), Motivation (٣ questions), Side effects (١ question), Confidence and competence (٤ questions), Expectations and enjoyment (٦ questions), User-friendliness (٣ questions), Realism (٤ questions), Interaction/immersion (٢ questions) and Future potential (١ question).

Scoring system of students' opinions:

The students were asked to rate items on a ٥-point Likert scale, ranging from (١) strongly disagree, (٢) Disagreed, (٣) Neutral, (٤) Agreed to (٥) strongly agree. The total scores ranged from ٢٧-١٣٥. Accordingly, the total level was categorized to:

- Positive > ٦٠٪ at total score (> ٨١).
- Negative < ٦٠٪ at total score (< ٨١).

Administrative design:

Prior to beginning the practical work, an official letter clarifying the aim of and nature the study was taken from the Dean of the Faculty of Nursing and Head of the Pediatric Nursing Department to perform the study. A clear explanation was provided about importance and the expected outcomes of the study.

Content validity:

Tools of data collection were designed and submitted to a jury of three experts (٢ professors and ١ assistant professor) in the field of paediatric nursing speciality from the Faculty of Nursing/Benha University to test the content validity of tools and judge its clarity, comprehensiveness, relevance, simplicity and accuracy. Based on experts' comments and recommendations, minor modifications had been made such as rephrasing, rearrangements or deleting some sentences to reach the final version of the tools. The tools were considered as valid from the experts' perspective.

Reliability of the tools:

The reliability of the developed and validated tools was estimated using the Chronbach's Alpha co-efficient. Test retest results using Chronbach's Alpha co-efficient reflected that all items were significantly differ and has a correlation above the threshold of significance. The internal consistency was ٠.٨٩ for students' knowledge assessment questionnaire, ٠.٨٣ for clinical evaluation checklist and ٠.٨٥ for virtual reality-teaching material usability questionnaire.

Ethical considerations:

A written approval was obtained from the Scientific Research Ethical Committee at the Faculty of Nursing/ Benha University. A written consent was taken from the students to share in the study. The students were informed that their participation in the study is completely voluntary and also they have the right to withdraw from the study at any time without any penalty. Anonymity and confidentiality were assured through coding the data. Moreover, participants were informed that data will not be reused for any research purposes without their permission. The study maneuver could not entail any harmful effects on students.

Pilot study:

A pilot study was carried out on ١٠٪ (٨ students) of the total study sample size to ascertain the clarity, relevance, feasibility, applicability of the study tools and sequence of questions to maintain consistency. Also, it helped to estimate the time needed to fill tools of data collection. Based on the results of the pilot study, no modifications were done and subjects under the pilot study were excluded from the main study sample. It was start from the beginning of February ٢٠٢٣ to the end of February ٢٠٢٣.

Field work:

The actual field work was implemented over a period of three months (from March ٢٠٢٣ to May ٢٠٢٣). At first, the researcher interviewed the pediatric nursing students to collect base line data at the Faculty of Nursing/ Benha University (in the ٣rd year pediatric nursing students' classroom) three days/week; Saturday, Monday and Wednesday according to their academic schedule from ٩.٠٠ A. M. and extended to ٣.٠٠ P. M. (by rotation in groups).

At the beginning of interview: the researcher welcomed the pediatric nursing students, illustrating the aim, technique, tools and outcomes

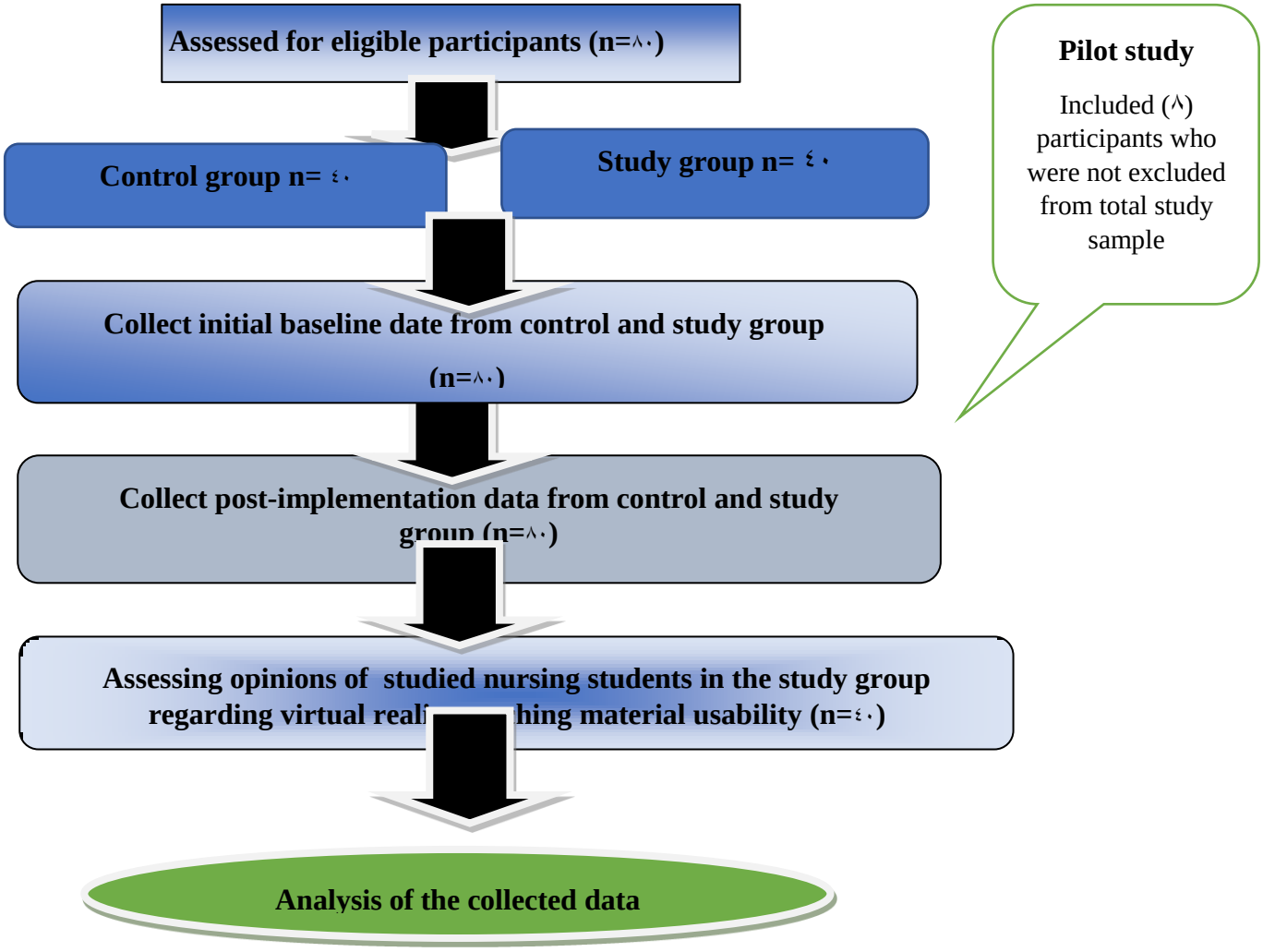
of the study and took their written approval to participate with study prior data collection. An average of ٣-٤ pediatric nursing students were interviewed per/day.

Then, the researcher gave pediatric nursing students (Tool I) to obtain their personal characteristics and assess their knowledge toward CPR and VR. The average time needed to complete it was between ١٥-٢٠ minutes. Also, the researcher observed each pediatric nursing student separately to assess their practices toward CPR at pediatric nursing skills laboratory by using observational checklists (Tool II). The average time required to observe each student was between ٢٥-٣٠ minutes.

After that, the researcher classified the pediatric nursing students into control and study groups equally and the researcher started to assess control group first to avoid bias. This took about one month (From the beginning of March to the end of March ٢٠٢٣).

For the control group:

The control group (٤٠) students were divided into sub-groups (every group was ٥ students) and distributed to ٢ pediatric nursing skills laboratory. These sub-groups took part in the traditional CPR demonstration enrolled in the third year pediatric nursing practical course and trained by assistant teaching staff in the traditional clinical sessions. The demonstration lasted for one hour, covering the background and technique of CPR, followed by practical training using the available equipment and CPR mannequin.



(Flowchart for data collection)

For the study group:

The researcher carried out a one day workshop (Sunday) for the pediatric nursing students in the study group and was conducted in the ٣rd year pediatric nursing students' classroom. The purpose was to orient the participants concerning VR and CPR. The session of VR from ٩.٠٠ A.M. to ١١.٠٠ A.M. and content of virtual reality lecture included (definition, indications, types, advantages, disadvantages it's applications of virtual reality in pediatric nursing education and tutor role) and another session about CPR from ١٢.٠٠ P.M. to ٢.٠٠ P.M. and content of CPR lecture included (definition, indication, signs and symptoms, complications, indication of ending CPR, appropriate nursing implementation, the landmark for chest compression performed, the method of giving chest compression, the correct rate of pressure on the chest, the ratio of pressure on the chest to the rate of breathing in children when there is only one paramedic, when there is two paramedic, the method of giving breathing, the methods of opening airway and which artery should check the child's plus).

Then, the study group (٤٠) pediatric nursing students were assigned to the pediatric nursing skills laboratory in sub-groups of around (٥) students each. The pediatric nursing students were trained regarding cardiopulmonary resuscitation by using VR ٣D glasses (The Meta Oculus Quest ٢) which illustrating the steps of CPR and the technique of chest compressions that designed by the researcher through specialized engineer under supervision of the supervisors.

Before training, the researcher provided brief instructions about how to utilize the VR technology that was directly followed by the VR-CPR training. Each student in the study group wore the VR eye glasses and was guided through VR-CPR scenario individually. First, the student was a passive observer and the scenario is repeated and each step was clarified by the researcher. Then, the student as active CPR provider, the scenario is repeated and the student carried out each step of the CPR independently. The scenario can only be continued, if all steps have been implemented. The practical training was conducted in the clinical pediatric nursing skill laboratory. The practical training took about ٣٠-٤٥ minutes for each student to practice on CPR using VR eye glasses. This took about six weeks (from the beginning of April ٢٠٢٣ to the middle of May ٢٠٢٣).

Evaluation

Evaluation of the effect of virtual reality as a teaching strategy on students' performance regarding CPR was implemented through using the same pre-test tools (Tool I & II) in both study and control groups immediately post VR implementation. Finally, the researcher assessed opinions of the pediatric nursing students in the study group about virtual reality-teaching material usability using posttest (tool III). This took about two weeks (from the middle of May ٢٠٢٣ to the end of May ٢٠٢٣).

Statistical design:

The collected data were revised, organized, coded, tabulated, and analyzed using Statistical Package for Social Sciences (SPSS) version ٢٠. Quantitative data were expressed as mean and standard deviation (SD). Qualitative data were expressed in form of frequency distribution tables, numbers and percentages. Qualitative variables were analyzed using Chi-Square test (x^2) & correlation coefficient (r) to determine the relation between variables of the study. The observed differences were considered as follows: Non-significant at P> ٠.٠٥, significant at P< ٠.٠٥ and highly significant at P< ٠.٠٠١.

Results:

Table (١) reflects that, the vast majority (٩٠٪) and all (١٠٠٪) of both study and control groups were in the age group of ٢٠ < ٢٢ years, with a mean age of ٢٠.٥٣± ٠.٧٥ years and ٢٠.٦٨ ± ٠.٤٧ years respectively. As regards residence, this table reveals that, more than half (٥٢.٥٪) and less than two thirds (٦٥٪) of the studied students in both study and control groups were from rural area respectively. Concerning attending any CPR training courses using virtual reality, all (١٠٠٪) of students in both study and control groups didn't attend any CPR training courses using virtual reality.

Figure (١) reveals that, more than half (٥٥٪) and more than two thirds (٦٧.٥٪) of the studied nursing students in both study and control groups were females respectively.

Figure (٢) represents that, the vast majority and majority (٩٢.٥٪ & ٨٧.٥٪) of nursing students in both study and control groups had low knowledge level pre-VR implementation respectively. However, post-VR implementation that the vast majority and one third (٩٠٪ & ٣٥٪) of nursing students in both study and control groups had good knowledge level respectively.

Figure (٣): It's evident from that, all (١٠٠٪) of the students in the study group and the most (٩٥٪) of the students in the control group had incompetent total practices level regarding CPR pre-VR implementation. However, post-VR implementation, majority (٨٧.٥٪) of students in the study group and more than half (٥٢.٥٪) of students in the control group had competent total practices level regarding cardiopulmonary resuscitation.

Figure (٤) reveals that, the vast majority (٩٠٪) of the nursing students in the study group had positive opinion about virtual reality-teaching material usability post-VR implementation. While, only ١٠٪ of them had negative opinion about virtual reality-teaching material usability post-VR implementation.

Table (٢) clarifies that, there was a statistical significant positive correlation between total knowledge score and total practice score in the study and control group pre-VR implementation (r=٠.٤٨٩, P=٠.٠٠١ versus r=٠.٤٢٦, P=٠.٠٠٦) respectively. Moreover, there was a highly statistical significant difference positive correlation between total knowledge score and total practice score in both study and control group post-VR implementation (r=٠.٨١٥, P=٠.٠٠٠ versus r=٠. ٦٩٣, P=٠.٠٠٠) respectively.

Table (٣) reflects that, there was a highly statistical significant positive correlation between total opinions and total knowledge scores in the study group post-VR implementation (r=٠.٦٣٧, P=٠.٠٠٠). Additionally, there was a highly statistical significant positive correlation between total opinions and total practice scores in the study group post-VR implementation (r=٠.٨٤٦, P=٠.٠٠٠)

Table (١): Distribution of the studied nursing students in both study and control groups according to

Groups / Variables	Study group n=٤٠		Control group n=٤٠	
	No.	%	No.	%
Age (years)				
< ٢٠	٣	٧.٥	٠	٠.٠
٢٠ < ٢٢	٣٦	٩٠.٠	٤٠	١٠٠.٠
٢٢ < ٢٤	١	٢.٥	٠	٠.٠
Mean ± SD	٢٠.٥٣ ± ٠.٧٥		٢٠.٦٨ ± ٠.٤٧	
Residence				
Rural	٢١	٥٢.٥	٢٦	٦٥.٠
Urban	١٩	٤٧.٥	١٤	٣٥.٠
Attending any CPR training courses using virtual reality				
No	٤٠	١٠٠.٠	٤٠	١٠٠.٠

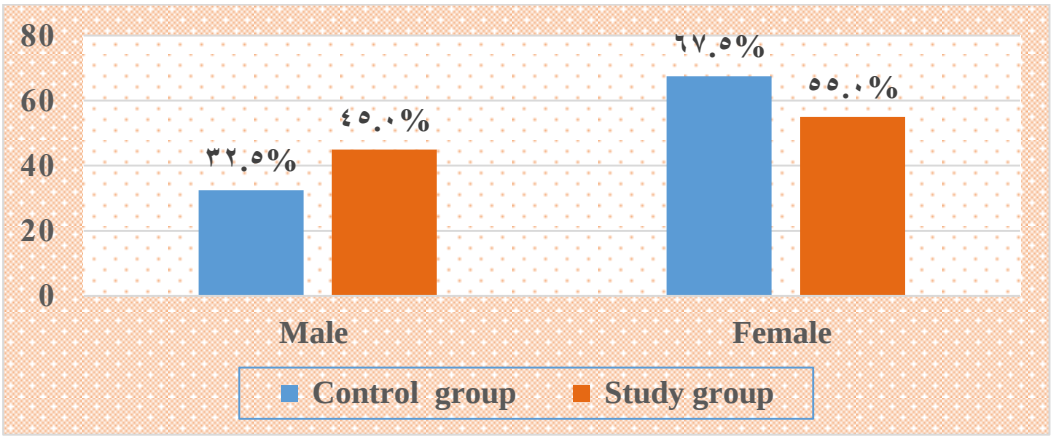


Figure (١): Distribution of the studied nursing students in both study and control groups according to their gender (n=٨٠)

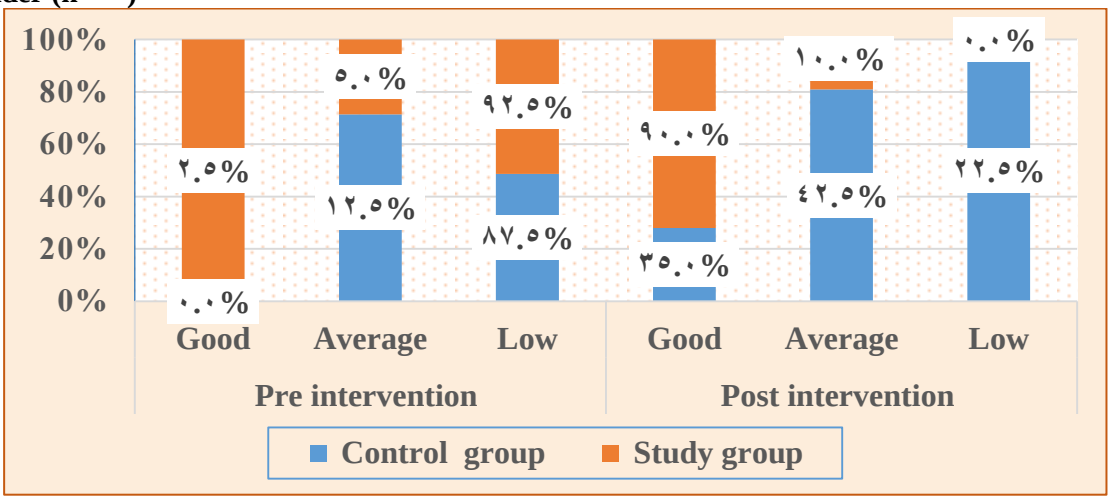


Figure (٢): Distribution of the total studied nursing students' knowledge level in both study and control groups regarding cardiopulmonary resuscitation and virtual reality pre and post- VR implementation (n=٨٠).

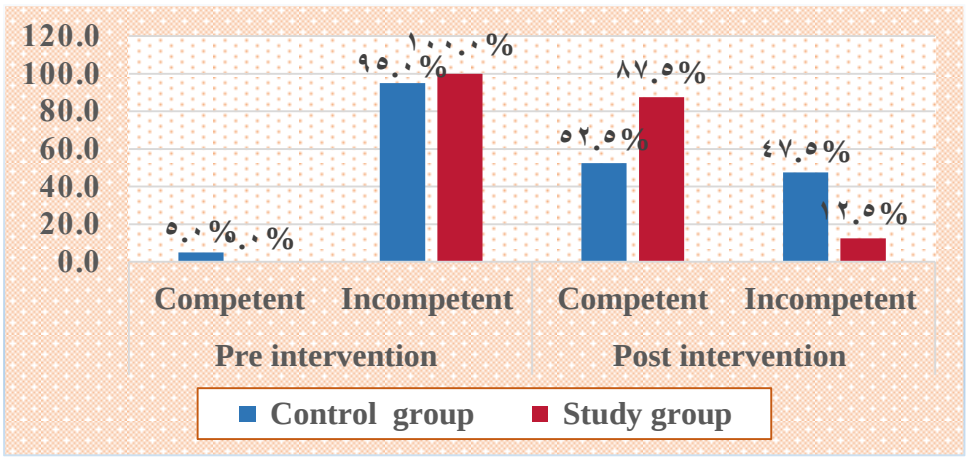


Figure (٣): Distribution of the studied nursing students in both study and control groups according to their total practices level regarding CPR pre and post- VR implementation (n=٨٠).

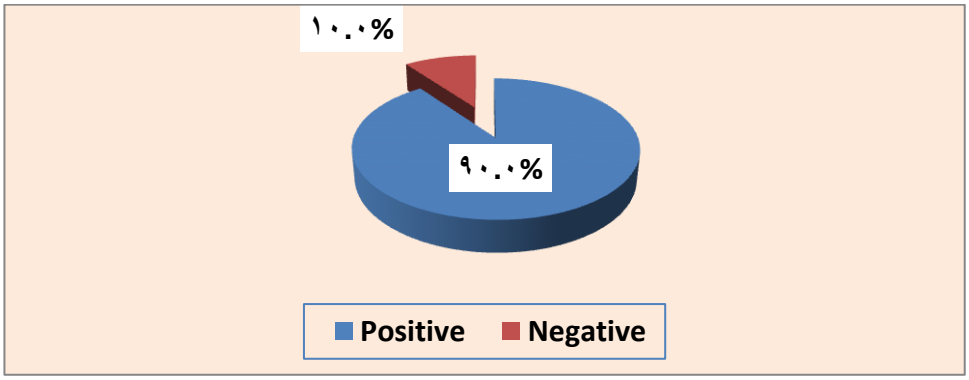


Figure (٤): Distribution of the studied nursing students in the study group according to total level of opinion about virtual reality-teaching material usability (n=٤٠).

Table (٢): Correlation coefficient between total knowledge and practice scores regarding cardiopulmonary resuscitation and virtual reality pre and post-VR implementation in both the study and control groups (n=٨٠).

Variables		Total knowledge score			
		Study group n=٤٠		Control group n=٤٠	
		r	P	r	p
Total practice score	Pre implementation	٠.٤٨٩	٠.٠٠١**	٠.٤٢٦	٠.٠٠٦*
	Post implementation	٠.٨١٥	٠.٠٠٠**	٠.٦٩٣	٠.٠٠٠**

Table (٣): Correlation coefficient between total opinions about virtual reality usability and total knowledge and practice scores post-VR implementation in the study group (n=٤٠)

Study group		
Variables	Total opinions score n=٤٠	
	r	p
Total knowledge score	٠.٦٣٧	٠.٠٠٠**
Total practice score	٠.٨٤٦	٠.٠٠٠**

Discussion:

Technology enhanced education has been found to perfect retention and ease competency assessment, especially in CPR, thus the European resuscitation council have advocated the application of virtual learning as a format of pre-course e-learning, providing a new way for a blended learning (**Greif et al., ٢٠٢١**). With the rapid progress of information technology, a transformation of nursing education is required to prepare nursing students for evolving and complex health care environments. The revolutionary advancement of highly immersive digitized learning resources like virtual reality simulators harnesses the advantages of simulation while providing a cost-effective and vastly attainable educational platform. Also, using of VR simulators for procedural skills training improves intraoperative performance and accuracy and reduce operating times and errors (***Chen et al., ٢٠٢٠ & Perron et al., ٢٠٢١***).

Virtual reality assists the learner to be immersed into the virtual environment, that provides a more realistic technique of teaching than traditional methods, enhancing on the students' psychomotor skills, providing a mean of constructive learning with prompt feedback and also, developing the confidence of users without causing risk to pediatric patients (***Jaskiewicz et al., ٢٠٢٠ & Imran et al., ٢٠٢١***). VR was supported by the American Heart Association as a good education method which highlighted the part of immersive technologies in the development of CPR education strategies to develop the learning experience of learners (***Alcázar Artero et al., ٢٠٢٣***).

Several studies have been published in the past few years on VR for CPR training and provided evidence for the usage of VR simulations for improving knowledge and enhancing procedural skills regarding BLS. VR enables increased numbers of students to actively share in an immersive simulated learning environment at their own pace, in their own time and venue. Also, it provided authentic and positive learning experiences for nursing students (***Bani Salameh et al., ٢٠٢٤, Kiegaldie & Shaw, ٢٠٢٣, Liu et al., ٢٠٢٣,*** **Moll Khosrawi et al., ٢٠٢٢ and** ***Woon et al., ٢٠٢١ & Perron et al., ٢٠٢١***). Thus, the aim of the present study was to evaluate the effect of virtual reality as a teaching strategy on pediatric nursing students' performance regarding cardiopulmonary resuscitation.

The results of the current study showed that, the vast majority and all of both study and control groups were in the age group of ٢٠ < ٢٢ years, with a mean age of ٢٠.٥٣± ٠.٧٥ years and ٢٠.٦٨ ± ٠.٤٧ years respectively. These results agree with ***Yang et al., (٢٠٢٠)*** who studied "Immersive virtual reality-based cardiopulmonary resuscitation interactive learning support system" and revealed that, the ages of participants were ١٩ to ٢٣ years. Additionally, these findings agree with ***Liu et al., (٢٠٢١)*** who conducted a study entitled "Effects of immersive virtual reality cardiopulmonary resuscitation training on prospective kindergarten teachers' learning achievements, attitudes and self-efficacy" and pointed that, the mean age of participants was ٢١.٢٨±١.٤٠ years and ١٩±١.٠٨ years in VR group and control group respectively.

As regards residence, this study revealed that, more than half and less than two thirds of the studied nursing students in both study and control groups were from rural area respectively. This may be contributed to most of students in the faculty of nursing in Qalyubiyah Governorate come from rural areas This result is consistent with ***Abd Al Karem et al., (٢٠٢٢)*** in a study entitled "Effect of a Simulation Intervention on Maternity Nurses' performance regarding Cardiopulmonary Resuscitation" who found that, more than half of the participants were from rural areas. Also, this result agrees with ***Mohamed, (٢٠١٧)*** in a study entitled "Effect of Cardiopulmonary Resuscitation (CPR) Training Program on Knowledge and Practices of Internship Technical Institute of Nursing Students" who showed that, less than two-thirds of the studied nursing students were from rural areas.

Concerning attending any CPR training courses using virtual reality, all of nursing students in both study and control groups didn't attend any CPR training courses using virtual reality. This may be due to VR is a new technology and the nursing students didn't have the opportunity to practice it due to unavailability of VR training and resources. These results are in the same context with ***Bjelovucic et al., (٢٠٢٣)*** who assessed "Dental students' attitudes on cardiopulmonary resuscitation training via virtual reality" and reported that, most of the students had not utilize VR previously for CPR training.

Moreover, these findings agree with **Moll-Khosrawi et al., (٢٠٢٢)** who assessed "Virtual reality as a teaching method for resuscitation training in undergraduate first year medical students during COVID-١٩ pandemic: a randomized controlled trial" and reported that, only ٤.٣٪ and

١١.٩ of students in both intervention and control groups had previous VR experience.

In relation to gender, the present study showed that, more than half and more than two thirds of the studied nursing students in both study and control groups were females respectively. This could be attributed to increasing number of females studying in the faculty of nursing than males and the greater fraction of the nurses in Egypt was females. These results agree with ***Nas et al., (٢٠٢٢)*** who studied "Long-term effect of face-to-face versus virtual reality cardiopulmonary resuscitation training on willingness to perform CPR, retention of knowledge and dissemination of CPR awareness" and found that, less than two-thirds and more than half of participants were females in both face-to-face and VR groups.

Concerning knowledge level of nursing students under the study regarding cardiopulmonary resuscitation and virtual reality pre-VR implementation, the results of the present study illustrated that, the vast majority and majority of nursing students in both study and control groups had low knowledge level respectively. The insufficient level of understanding among the nursing students regarding CPR prior to VR implementation may be linked to the fact that all nursing students in both study and control groups didn't attend any CPR training using VR due to unavailability of its' resources. Also, most of the nursing students acquire knowledge through the traditional teaching methods which are more inclined to be forgotten.

This result of the present study is supported by **Tang et al., (٢٠٢١)** who performed a study entitled "Virtual Reality or Video-Based Self-Instruction: Comparing the Learning Outcomes of Cardiopulmonary Resuscitation Training" and reported that, the average CPR knowledge of the virtual reality and video groups was low in the pretest. Also, **Kiegaldie and Shaw, (٢٠٢٣)** who assessed "Virtual reality simulation for nursing education: effectiveness and feasibility" demonstrated that, results of knowledge level was low in both control and intervention groups pre-intervention.

While, post-VR implementation, the vast majority of nursing students in the study group had good knowledge level compared to one third of them in the control group. This emphasized that nursing students' knowledge is positively impacted by the application of the VR training scenario which could potentially boost the learning experience and this improve their knowledge, procedural memory and transfer knowledge to real-world scenario. Also, teaching based on VR technology could assist nursing students get a deeper impression and maintain long-term memory as students become more interactive and engaged in a real environment. This is proved by ***Perron et al., (٢٠٢١)*** who stated that, engaging sensory modalities of VR technology involving vision, haptics, and audition fosters active learning, that in turn can upgrade memory retention.

These results are in harmony with ***Barsom et al., (٢٠٢٠)*** in a study entitled "Cardiopulmonary resuscitation training for high school students using an immersive ٣٦٠-degree virtual reality environment" who found that, VR group had significantly higher level regarding CPR knowledge than in the standard group post training (P=.٠٣٥). Moreover, the results of the present study is corresponding with ***Liu et al., (٢٠٢٣)*** who evaluated "Effectiveness of virtual reality in nursing education" and determined that, using of VR technology was effective in developing students' theoretical knowledge compared to other traditional nursing teaching means.

Regarding total practices level of the studied nursing students in both study and control groups regarding CPR, the finding of the present study reflected that, all and most of the nursing students in both study and control groups had incompetent practices level regarding CPR pre-VR implementation. According to the researcher's perspective, the incompetent practices level of nursing students under study before training may be related to lack of training regarding CPR by virtual reality.

This finding is in concurrence with ***Tang et al., (٢٠٢١)*** who pointed that, the ability of participants in both virtual reality and video groups to perform cardiopulmonary resuscitation was low and there was no significant difference between the willingness of participants in the virtual reality group and the video group to perform cardiopulmonary resuscitation in the pretest.

On the same scope, the results of the current study are compatible with ***Hubail et al., (٢٠٢٢)*** in a study entitled "Comparison of a virtual reality compression-only Cardiopulmonary Resuscitation (CPR) course to the traditional course with content validation of the VR course" who found that, skill level was low at baseline assessment in both groups and the comparison of baseline skills reflects no statistically significant

differences between the two groups, indicating both groups started at the same skill levels.

Virtual reality simulation enhanced performance in realistic clinical settings ***(Bani Salameh et al., ٢٠٢٤)***. This result matches with the result of the present study which pointed that, majority and more than half of nursing students in both study and control groups had competent practices level regarding cardiopulmonary resuscitation post-VR implementation.

From the researcher's point of view, this could be contributed to nursing students have the chance to be involved in repetitive practice until achieving educational mastery in a safe and controlled environment, that is an essential advantage of VR technology as this is severely limited in real-world emergency patient encounters, especially in the pediatric patients. Additionally, the flexible designing of VR may help health care professionals to have more appropriate and numerous opportunities to demonstrate and refine skills.

These results are corresponding with ***Yang et al., (٢٠٢٠)*** who showed that, ١٠٪ of participants performed the CPR successfully, whereas ٩٠ % failed pre intervention. After implementing VR-CPR training, ٨٥٪ performed CPR simulation successfully and ١٥٪ failed. The post-intervention scores were significantly higher than the pre-intervention scores (P<٠.٠٠١). Additionally, ***Liu et al., (٢٠٢٣)*** showed that, application of VR technology in teaching exhibits a disparity in nursing practical skills and added that, there was a statistically significant difference compared to other traditional nursing teaching methods (P < ٠.٠٠١).

Regarding total opinions level of the nursing students about virtual reality-teaching material usability in the study group, the present study revealed that, the vast majority of nursing students had positive opinions level about virtual reality-teaching material usability. The positive opinion level may be contributed to increasing understanding, motivation, confidence and competence, expectation and enjoyment, user friendliness, realism and interaction after using virtual reality technology for CPR training.

The results of the current study agree with ***Domingo and Bradley, (٢٠١٨)*** who carried out a study entitled "Education Student Perceptions of Virtual Reality as a Learning Tool" and revealed that, ٥٢٪ of students had an overall positive perception of VR experience, ٣٨٪ of students had an overall negative perception and ١٠٪ of students reported having mixed feelings about the experience.

Also, these results are corresponding with ***Bjelovucic et al., (٢٠٢٣)*** who highlighted that, the overall experience of utilizing VR in CPR training was categorized as very good, whereas, most of participants were interested in attempting the scenario again and almost of participants would recommend the VR technology to others.

In relation to correlation between total knowledge and total practice scores, the current study revealed that, there was a statistical significant positive correlation between total knowledge score and total practice score in the study and control groups pre and post VR implementation. This ascertains that application of VR in nursing education lead to more effective development in theoretical knowledge and mastering of practical skills. Also, a higher level of interactivity is more effective for the enhancement of post-VR implementation knowledge and skills.

The finding of the present study is in harmony with ***Mahmoud et al., (٢٠٢٤)*** who evaluated "Effect of Virtual Lab Training for critically care Nursing students on Achievement Competency Basic Skills" and reflected that there was a positive correlation between total level of knowledge and total competent level of skills among students included in the study during third observations with P value = (٠.٠٠١*).

Concerning correlation between total opinions and total knowledge scores, the findings of the present study illustrated that, there was a highly statistical significant positive correlation between total opinions and total knowledge scores in the study group post-VR implementation. Additionally, there was a highly statistical significant positive correlation between total opinions and total practice scores in the study group post-VR implementation. This could be attributed to improvement of students' knowledge and their practices after using VR as a teaching strategy leads to enhancing students' opinions regarding virtual reality.

The aforementioned result is supported by ***Mahmoud & Abdel-Salam, (٢٠١٨)*** who evaluated "The Effect of Interactively Virtual Reality Eyeglasses on The of Pediatric Nursing Students Performance" and illustrated that, there was a highly statistical significant positive correlation between total knowledge, practice and attitude score toward virtual reality environment in study group (P value <٠.٠٠١).

Conclusion:

Virtual reality as a teaching strategy was effective in improving knowledge and enhancing practices of pediatric nursing students regarding CPR.

Recommendations:

For nursing practice:

- Integrating virtual reality technology in nursing clinical courses to reinforce their performance in clinical settings.

For nursing education:

- Adoption of VR in higher education to create more engaging, effective, and personalized learning environments.

For faculty administration:

- Recommend virtual reality resources in the nursing colleges for nursing students to promote practice of nursing skills in natural and real life like settings.

For future nursing research:

- Future research in virtual reality should continue to explore the long-term effects of VR technology on students' learning and engagement.
- More researches are required to validate application of VR training for development of skill proficiency related to different pediatric nursing skills.

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