
Effect of Simulation linked Problem-Based Learning Strategy on Nursing Students' Performance Regarding Care of Children Undergoing Open Heart Surgery

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Abstract:

Background: Simulation linked Problem-based Learning (S-PBL) is a strategy, through which the students learn effectively while introducing students to real-world scenarios and professional nursing procedures. **Aim of the study:** to evaluate the effect of simulation linked problem based learning strategy on nursing students' performance regarding care of children undergoing open heart surgery. **Setting:** clinical pediatric laboratory skills, laboratory simulation-based training and teaching hall of Faculty of Nursing/ Benha University. **Subjects:** A simple random sample was used for the purpose of sample selection. A quasi-experimental research design was utilized **Tools of data collection:** three tools were utilized; Pediatric Student-Nurses' Knowledge Assessment Sheet, Observation Checklists And Barriers of Using Problem-Based Learning Strategy Questionnaire. **Results:** Minority (1%) versus most (95%) of the studied students had good total knowledge level pre/post the S-PBL strategy application respectively. Minority (3%) versus most (92%) of the studied students had competent level of practice pre/post the S-PBL strategy application respectively. Minority (4%) versus most (98%) of studied student had positive perspective toward barriers of using PBL strategy pre/post S-PBL strategy application. **Conclusion:** Students had higher levels of knowledge and practices post strategy application than pre application. Also, the barriers faced by the studied students regarding PBL reduced. **Recommendation:** the S-PBL strategy application is encouraged to be on larger sample size and on most faculties of nursing in Egypt. Application of PBL strategy needs to be done on a larger sample number.

Keywords: *learning strategy, Open heart surgery, Performance, Simulation linked Problem based learning & Student nurses.*

Introduction:

Problem based learning (PBL) is a teaching style which encourage students to be innovative, creative, open-minded, active, logical, decision makers and the drivers of their learning. PBL uses complex, real-world issues including (lessons, units, or even entire curricula, the classroom's subject matter); PBL encourages students problem-solving skills development, dialogue and discussion, offers opportunities for the students to collaborate with others in a team in a hands-on, team maintenance, team leadership, conflict management and concepts understanding. Simulation based learning (SBL) is a teaching methodology presenting similar situations to those in the actual hospital settings, enabling the students from understanding the professional environment using the problem solving approach (Kim & Chun, 2018).

Combining both SBL and PBL, is called Simulation linked Problem based Learning Strategy (S-PBL), through which the students learn effectively while

being clinically trained in professional manner, enhancing the nursing students' confidence, as immediate feedback between teacher and learner is followed. In the field of nursing education, S-PBL enables nurses from developing the skills of problem-solving crucial for solving the various clinical health problems. Nursing students who exposed to clinical scenarios simulations, after graduation can solve various patient health problems (Hirsch & Fromm, 2021; & Yang & Lee, 2018; & Kim, 2017).

Congenital heart defects (CHDs) as birth defect is the most common type and the birth defect-associated infant morbidity and mortality leading cause. CHDs, vary in severity from mild (as heart small hole) to severe (as missing or poorly developed parts of the heart). Signs and symptoms for CHDs vary according to the particular defect type and severity; some defects might be a symptomatic, others may have minimal signs and symptoms; others might cause a neonate present with varied symptoms, including dyspnea, blue-tinted skin, tiredness when feeding,

sleepiness and swollen body tissues or organs. The CHDs is categorized as non-cyanotic and cyanotic (Thomford et al., 2020).

Non-cyanotic CHD such as (Bicuspid Aortic Valve (BAV), Aortic Stenosis (AS), Coarctation of the Aorta (CoA), Atrial Septal Defect (ASD), Ventricular Septal Defect (VSD), Atrioventricular Canal (Endocardial Cushion Defect), Patent Ductus Arteriosus (PDA), Pulmonic Stenosis (PS), while cyanotic CHD which is also called Critical Congenital Heart Disease (CCHD) including (Hypoplastic Left Heart Syndrome (HLHS), Ebstein Anomaly (AE), Tetralogy of Fallot (ToF), Pulmonary Atresia (PA), Total Anomalous Pulmonary Venous Return (TAPVR), Tricuspid Atresia and Truncus Arteriosus, Transposition of the Great Vessels (ToGVs), Double-outlet Right Ventricle, Single Ventricle (SV) and Interrupted Aortic Arch (IAA) (The National Center on Birth Defects and Developmental Disabilities, 2022; & Segura & Gatzoulis, 2019)

Caring for children suffering from CHDs is challenging; the pediatric nurse should establish a good nurse-child as patient relationship, educate the children and their parents regarding the disease/defect diagnosis, clinical manifestations, parental role and precautions regarding the indicated surgery. In addition to that, the pediatric nurse should make a living system suitable for the children's activities according to their condition, prevent infection while maintaining self-protection measures for both children and their parents, monitor the children's vital signs, confirming the necessity of avoiding contact with patients suffering from infectious diseases. Air refreshment in the ward is a must and even; once an infection occurs, it should be treated actively to avoid the occurrence of complications. In addition, the pediatric nurses should instruct children regarding nutrition to be highly enriched with a high protein, calories and vitamin to enhance their physical fitness (Magalhães et al., 2016).

Significance of the study:

Quality of education improvement is highly necessary for having a more professional world; although problems based learning (PBL), was developed more than 30 years ago, it has shown to be one of the most suitable methodologies for obtaining meaningful learning (Henderson, 2016). The researchers adopted the simulation linked problem based learning (S-PBL) strategy for caring of children undergoing open heart surgery, where nursing students have minimal/rare close observation, practical opportunities and direct care for these children. Simulation education has the merit of providing safe repetitive exposure to the difficult situations experienced in actual clinical practice allowing students to learn procedures in a

standardized way and gain the necessary experience (Kim & Chun, 2018 ; & Joseph et al., 2016). Congenital heart disease is a chronic disease resulting from birth structural anomaly or heart defect. Worldwide, about 9 in 1000 are born with these abnormalities. The incidence of CHD among Egyptian children estimated to be 5-6/1000 live birth (Emteres et al., 2019). Each year, an estimated 1.3 million children are born with CHD, of which 90% living in developing countries receive either less than optimal care or do not have access to cardiac care they desperately need (Murala et al., 2019). 250,000 global deaths have been annually attributed to untreated CHD (Polivenok et al., 2020; & Novick et al., 2019). It is estimated that 35% of infant mortality because of cardiovascular anomalies (Oster et al., 2013). Around 25% of children born with CHDs, have CCHD require cardiac surgery or other interventions for survival or other procedures in the first year of life (Bakker et al., 2019). So the current study was aimed to improve nursing students' performance regarding care of children undergoing open heart surgery.

Aim of the Study:

The present study aimed to evaluate the effect of simulation linked problem based learning strategy on nursing students' performance regarding care of children undergoing open heart surgery; through the following specific objectives:

- 1.To assess pediatric nursing students' knowledge and practice regarding CHDs and open-heart surgery
- 2.To assess barriers facing the pediatric nursing students regarding the PBL application.
- 3.Design and implement S-PBL strategy for pediatric nursing students regarding CHDs and open-heart surgery.
- 4.Evaluate the effects of the designed S-PBL strategy on pediatric nursing students' knowledge and practice regarding CHDs and open-heart surgery.

Subjects and Methods:

Research design: A quasi-experimental research design (one-group pretest-posttest design) was utilized to achieve the aim of the present study.

Setting:

The current study was conducted in clinical pediatric laboratory skills for third year students. Laboratory simulation-based training and teaching hall in the Faculty of Nursing\ Benha University. Laboratory skills consisted of two rooms, first room called clinical pediatric laboratory skills (1), and the second room called clinical pediatric laboratory skills (2), each room contains "patient" (mannequin) bands and hospital gowns. Each bed area is equipped with cabinet stand and an over-the-bed tray. A panel with realistic appearing oxygen, air, and suction outlets and a container for the proper disposal of sharps are

available above each bed. Three researchers from Benha University were working in the same time in different labs in parallel way.

Subject:

The study subjects was consisted of a random sample out of 600 pediatric nursing students from pediatric nursing department; third year, who enrolled in the academic year 2022/2023 at the Faculty of Nursing\ Benha University.

Sampling technique:

A random sampling technique, was conducted to select the studied sample, the sample size was calculated using G* power software version 3.1.9.2 and based on a previous study done by (Saied, 2017), which evaluate the impact of Simulation on Pediatric Nursing Students' Knowledge, Self-efficacy, Satisfaction, and Confidence, input parameters, expected effect size $d = 0.393$, α error = 0.05, power $(1-\beta) = 0.95$, resulting output parameter was total sample size of 86 students, to increase validity of results and allowing for drop out or missed data during the study of about 16% , the sample size was adjusted and increased to 100 students.

Tools of data collection:

Data of the present study was collected by using three tools as following:

Tool (I): Pediatric Student-Nurses' Knowledge Assessment Sheet:

This tool was adapted from Gale et al., (2020); & El-Razky et al., (2019) and modified to suite the nature of the study. It consisted of two parts:-

Part (1): Characteristics of the studied pediatric nursing students; age, gender and qualification before attachment to the faculty (3 questions).

Part (2): Student Nurses' Knowledge About Both Pediatric Congenital Heart Diseases, Cardiac Catheterization And Open-Heart Surgery;

Questions regarding congenital heart diseases were in the form of ten multiple-choice questions which included (fetal circulation, etiology of congenital heart defects, manifestation of Atrial Septal Defect, therapeutic management of Ventricular Septal Defect, definition of Patent Ductus Arteriosus, manifestation of Coarctation of the Aorta, definition of Aortic Stenosis, manifestation of Pulmonic Stenosis, complication of open heart surgery and nursing role in prevention of digoxin toxicity. There were other ten open-ended questions about classification of congenital heart diseases, complication of Tetralogy of Fallot, clinical picture of Tricuspid Atresia, manifestation of Transposition of the Great Vessels, definition of heart murmur.

Questions regarding cardiac catheterization (indication and nursing role during cardiac catheterization), **and open heart surgery** (definition, preoperative preparation and nursing care of children undergoing open-heart surgery).

Scoring system of pediatric student-nurses' knowledge

The studied students' answers were compared with the model key answer, two scores were given for complete correct answer, one score was given for incomplete correct answer and zero score was given for wrong answer and unknown answer. According to the students' responses, their total level of knowledge was considered Poor level if the obtained total scores was (less than 50%) (Less than 20 points), while their knowledge total level was considered Average level, if the obtained total scores was (50% to less than 75%) (from 20 to less than 30 point) and their knowledge total level was considered Good level if the obtained total scores was (75% to 100%) (From 30 to 40 point).

Tool (II): Observational checklists:

This tool was adopted from Lynn, (2015) to assess student nurses' practice regarding pre, during and post-operative management of children undergoing open heart surgery. It included vital signs, lower extremity pulse, measurement of weight, measurement of fluid intake and output, care of child on ventilator, mobility exercises, oropharyngeal /nasopharyngeal suction, endotracheal tube suction, breathing exercises, removal of chest tube, intravenous infusion therapy, wound care, providing urinary catheter care and removing it.

Scoring system of student-nurses' practice

The studied student's practices were compared with the observational check list; where one score was given for each step done correctly and zero score for step done incorrectly or not done. According to the students' responses, their total level of practice was considered incompetent if the obtained total mean scores was (less than 75%) and their total level of practice was considered competent if the obtained total mean scores were (75% to 100%).

Tool (III): Barriers of using problem-based learning strategy questionnaire:

It was adapted from Abd-El Rasoul et al., (2020) based on instruments used by Othman & Shalaby, (2014); and modified by the researchers to suite nature of the study. This part includes (12) statements regarding detecting nursing students' perspective in relation to the faced barriers of using problem-based learning strategy. This part includes questions related to lack of information about PBL and its technique, difficulties in information search, heavy workload and lack of facilities such as (computer labs, data shows and references).

Scoring system of barriers of using problem-based learning strategy

It is 3-point-Likert scale which is used to assess the degree of agreement of barriers. It ranges from; never (0), sometimes (1), mostly (2) and always (3). The total scores of students' perspective regarding barriers of using problem-based learning strategy were between (12 to 36 point) was considered negative

students' perspective if the obtained total mean scores was ($< 60\%$) (Less than 22 point). Meanwhile, if the obtained total mean scores was ($60\% \leq 100\%$) (22 to 36 point), it was considered positive students' perspective.

Operational Design:

The operational design included the preparatory phase, content validity, reliability of the study tools, pilot study, and fieldwork.

Preparatory phase: It involves searching the national and international related literatures using periodicals, textbooks, internet, journals and theoretical knowledge of the different aspects concerning the topic of the study to gather the tools of the study.

Content validity and Reliability:

Tools Validity: tools of data collection were investigated for its' content validity by three juries in pediatric nursing from the Faculty of Nursing Benha University, who are experts in the related field and chosen to test the study tools' content validity and to judge its relevance, comprehensiveness, clarity, accuracy and simplicity. The researchers considered the experts' remarks as some items were re-phrased to have the final tools version and the experts referred to the study tools as valid.

Tools Reliability: Cronbach's coefficient alpha of pediatric student-nurses' knowledge assessment sheet is 0.90. Cronbach's coefficient alpha of barriers of using problem based learning strategy assessment sheet is 0.75.

Administrative and Ethical Considerations:

All the relevant principles of ethics in research were pursued as the study proposal was approved by the Scientific Research Ethics Committee of the Faculty of Medicine, Benha University Code (Study No. Rc.36.9-2022); an official letter verifying the study purpose was obtained from the Dean of the Faculty of Nursing for the study conduction. An official written consent was obtained from participants in data collection regarding their acceptance to participate in the study. Participants were informed about their rights to participate in, refuse, or withdraw at any time. Any obtained data was very confidential and the study would not cause any harm.

Pilot Study:

A pilot study was conducted in the first week of October 2022, to test the clarity and applicability of the study tools and estimate the time needed for each tool. It was done on 10% of the total subjects, they were included in the present study as there was little modifications were done in the study tools.

Statistical analysis:

the collected data was coded and entered to the statistical package of social sciences (SPSS version 20). After complete entry, data was explored for detecting any error, then, it was analyzed by the same program for presenting frequency tables with percentages. The following statistical techniques were

used percentage, Mean score degree, Standard deviation SD, t tes, Chi-square test (X^2) test, Pearson correlation (r test) and proportion probability of error (P - value). Significance of results was displayed as a statistically significant difference, when $P < 0.05$. A highly statistically significant difference was considered if $P < 0.01$.

Field Work:

assessment, planning, implementation and evaluation phases were adopted to achieve the current study aim; these phases started from the earliest of October 2022 to the beginning of December 2022, (duration of the study was two months and one week).

Assessment phase:

This phase involved interviews with the studied students to collect baseline data, at the beginning of interview; the researchers welcomed each student, explained the purpose, duration, and activities of the study, and took written consent from students. After that, Pre-test was done to assess studied students' knowledge, practice and barriers of using problem-based learning strategy by using pre-test tools (I, II & III). The data obtained during this phase comprised the baseline for further comparison to evaluate effect of problem-based learning strategy on pediatric nursing students' performance regarding care of children undergoing open heart surgery. The average time required for finishing each questionnaire was around (15-20 minutes). The pretest period took one week, (the second week of October 2022).

Planning phase:**Development of problem based learning and simulation based strategy requirements:**

The scenario of the problem for the brain storming session and the scenario for the simulation lab were developed by the researchers. Also, instructional media included colored poster about congenital heart defects and open-heart surgery. This phase took two weeks from the third week to the fourth week of October 2022.

Statement of objectives:**General objective:**

The main goal of this problem based learning strategy is to improve studied pediatric student nurses' performance regarding care of children undergoing open heart surgery.

Results:**Table (1): Distribution of the studied students according to their characteristics.**

Characteristics	(n=100)	
	No.	%
Age (years):		
19 ≤ 20	76	76.0
21 ≤ 22	24	24.0
Mean ±SD	21.07 ± 0.80	
Gender:		
Male	19	19.0
Female	81	81.0
Qualifications before attachment to the faculty:		
Associate degree of nursing	15	15.0
General secondary school	85	85.0

Table (2): Mean scores and standard deviation of the studied students' knowledge on pre/posttests

Knowledge	Pretest	posttest	t test	p-value
	Mean ± SD	Mean ± SD		
1-Description of fetal circulation.	.860±.426	1.97±.171	22.64	.000
2-Etiology of Congenital Heart Diseases.	.830±.450	1.90±.362	18.12	.000
3-Classification of Congenital Heart Diseases.	.823±.445	1.92±.320	18.07	.000
4-Manifestation of Atrial Septal Defect.	.800±.471	1.88±.356	18.60	.000
5-Therapeutic management of Ventricular Septal Defect.	.780±.483	1.89±.345	17.96	.000
6-Definition of Patent Ductus Arteriosus.	.831±.452	1.95±.219	20.85	.000
7-Manifestation of Coarctation of Aorta.	.862±.492	1.94±.234	20.42	.000
8-Definition of Aortic Stenosis.	.845±.436	1.93±.287	18.25	.000
9-Manifestation of Pulmonary Stenosis.	.880±.493	1.89±.326	17.23	.000
10-Complication of Tetralogy of Fallot.	.863±.326	1.97±.171	23.25	.000
11-Clinical picture of Tricuspid Atresia.	.840±.470	1.93±.352	20.24	.000
12- Manifestation of Transposition of Great Arteries.	.853±.465	1.92±.320	19.34	.000
13-Definition of heart murmur.	.820±.481	1.89±.396	17.65	.000
14- Indication of cardiac catheterization.	.734±.443	1.90±.345	18.56	.000
15-Nursing role during cardiac catheterization.	.821±.462	1.95±.219	21.34	.000
16-Nursing role in prevention of digoxin toxicity.	.862±.492	1.94±.234	20.43	.000
17-Definition of open heart surgery.	.865±.446	1.96±.287	22.42	.000
18- Preoperative preparation.	.880±.463	1.89±.326	18.31	.000
19-Complication of open heart surgery.	.862±.428	1.93±.181	21.85	.000
20-Nursing care of child undergoing open-heart surgery.	.870±.410	1.95±.462	22.78	.000

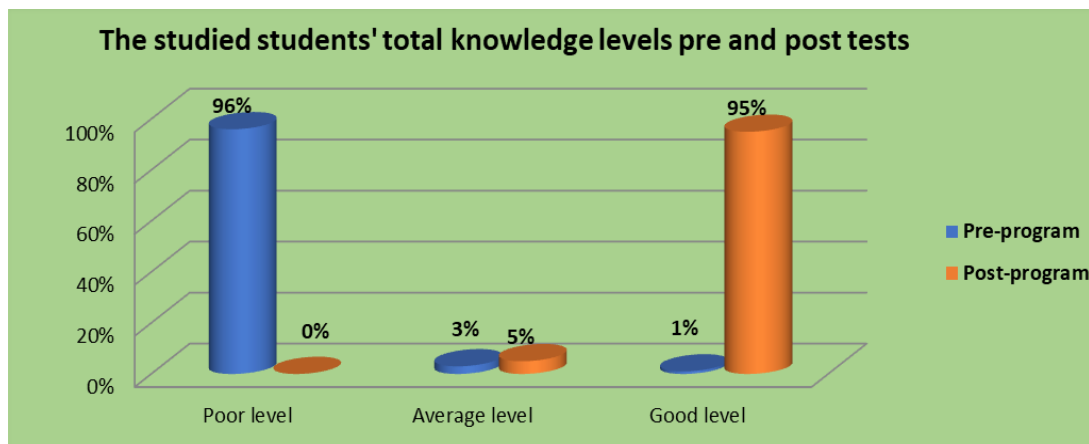


Figure (1): Distribution of the studied students according to their levels of knowledge pre/posttest.

Table (3): Distribution of the studied students according to their practice related to care of children undergoing open heart surgery on pre/posttest.

Nursing Procedure	Pre test				Posttest				X ² test FET	p value
	Done		Not done		Done		Not done			
	No.	%	No.	%	No.	%	No.	%		
Vital signs	14	14	86	86	98	98	2	2	143.1	.000
Lower extremity pulse	13	13	87	87	97	97	3	3	142.5	.000
Measurement of weight	11	11	89	89	99	99	1	1	156.4	.000
Measurement of fluid intake and output	7	7	93	93	93	93	7	7	147.9	.000
Care of child on ventilator	4	4	96	96	93	93	7	7	158.5	.000
Mobility exercises	4	4	96	96	97	97	3	3	172.9	.000
Oropharyngeal/Nasopharyngeal Suction	7	7	93	93	96	96	4	4	158.5	.000
Endotracheal tube suction	8	8	92	92	94	94	6	6	147.9	.000
Breathing exercises	7	7	93	93	94	94	6	6	151.3	.000
Removal of chest tube	2	2	98	98	95	95	5	5	173.1	.000
Intravenous infusion therapy	6	6	94	94	94	94	6	6	154.8	.000
Wound care	6	6	94	94	97	97	3	3	165.7	.000
Providing urinary catheter care and removing it	3	3	97	97	96	96	4	4	172.9	.000

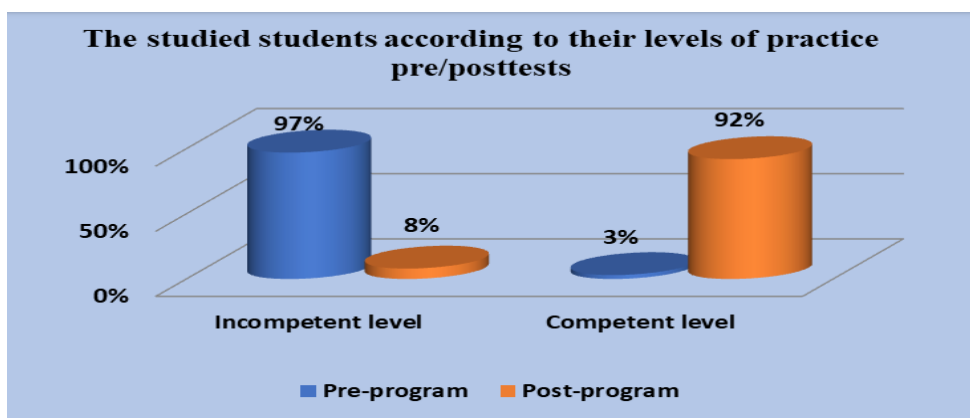


Figure (2): Distribution of studied students total according to their level of practice levels on pre and posttests.

Table (4): Mean scores and standard deviation of barriers toward PBL pre/ posttests.

Barriers	Pre test	Posttest	Paired t test	p value
	Mean ± SD	Mean ± SD		
Lack of information about PBL and its technique.	1.89±.314	3.36±.731	16.67	.000
Lack of commitment of students to their roles.	1.73±.446	3.16±.918	13.53	.000
Lack of direction of group team leader.	1.68±.468	3.55±.687	22.25	.000
Difficulties in information search.	2.02±.568	3.47±.688	20.25	.000
Heavy workload.	1.62±.487	3.30±.846	17.08	.000
Lack of motivation strategies.	2.06±.508	3.57±.700	19.23	.000
Lack of facilities such as computer, data shows, references.	1.94±.801	3.28±.753	11.95	.000
Time consumption.	1.93±.639	3.22±.938	11.78	.000
Difficulties to catch the key points.	1.99±.577	3.47±.610	14.23	.000
Presentation climate was stressful.	1.55±.500	3.36±.689	23.36	.000
Conflict within student's group.	1.41±.494	3.43±.623	24.02	.000
Difficulty in understanding the problem.	1.97±.822	3.72±.682	17.70	.000
Total	21.79±2.26	40.89±3.29	44.83	.000

**A highly statistically significant difference ($p \leq 0.001$)

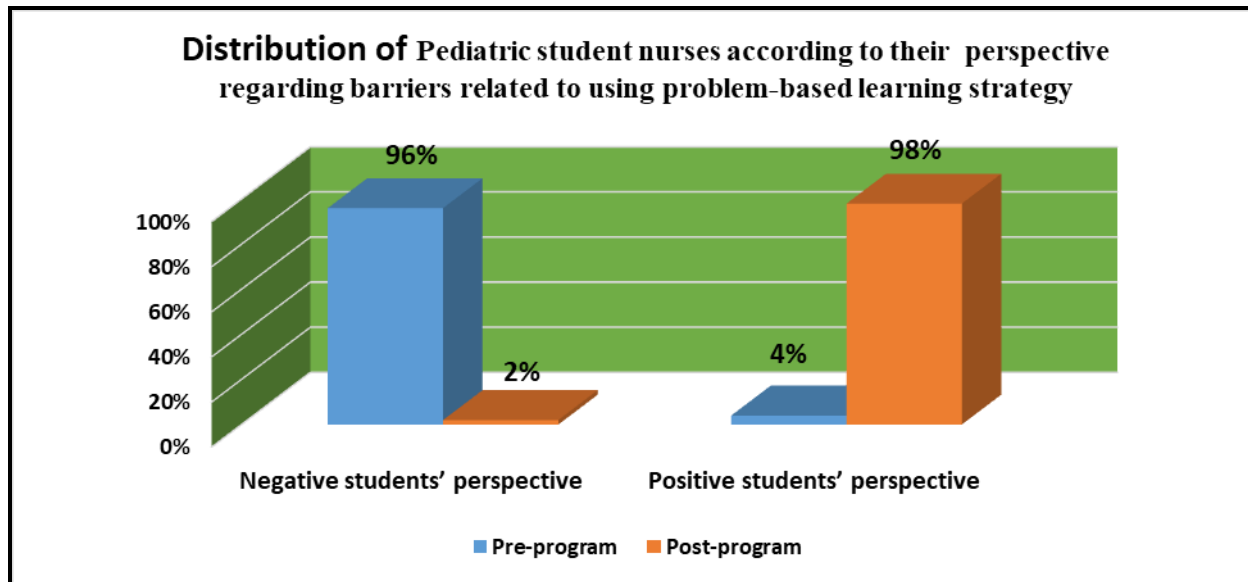


Figure (3): Distribution of pediatric student nurses according to their total perspective regarding barriers related to using problem-based learning strategy.

Table (5): Correlations coefficient between total knowledge and total practice scores among the studied students pre/posttests.

Total scores	Total knowledge scores			
	Pre test		Posttest	
	r	p value	r	p value
Total practice score	0.652	0.000**	0.514	0.000**

**A highly statistically significant difference ($p \leq 0.001$)

Table (1): Shows characteristics of studied students. More than three quarters (76%) were in age group $19 \leq 20$ with mean age 21.07 ± 0.80 . Regarding their gender, the majority (81%) of them were females. As far as qualifications level before joining to the faculty, the majority (85%) of them had secondary education.

Table (2): Illustrates that there was a very highly statistically significant improvement in studied students' knowledge on posttest than pretest, ($p \leq 0.000$).

Figure (1): Illustrates that, most (96%) of studied students had poor total-knowledge level on pretest. Otherwise, most (95%) of studied students had good total level of knowledge posttest.

Table (3): Illustrates that there was a highly statistically significant difference ($P \leq 0.001$) between students practices on pre/posttest. Also, most of them (98.0, 99.0 and 97.0) of them took vital signs, measured weight and performed wound care properly on posttest.

Figure (2): Shows that, most (97%) of studied students had incompetent level of practice pretest. Otherwise, most (92%) of them had competent level of practice posttest.

Table (4): Represents that there was a very highly statistically significant improvement in students perceptiveness of barriers on pre/posttest, ($P \leq 0.000$). Their perceptiveness of barriers toward PBL mean scores were higher on posttest than pretest.

Figure (3): Shows that 98.0% of studied students had positive perspective toward barriers of using problem based learning strategy posttest, compared to only 4% on pretest.

Table (5): Reveals that, there was a very highly statistically significant positive correlation between the studied students' total knowledge score and total practice score on pre and posttests ($P \leq 0.000$)

Discussion:

Congenital heart defects (CHDs) is a major worldwide wellbeing issue and one of the major childhood congenital irregularities. So, the current study aimed to evaluate effects of simulation linked problem based learning strategy on nursing students' performance regarding care of children undergoing open heart surgery.

According to student nurses' knowledge regarding CHD and open heart surgery, the findings of the current study revealed that most of the studied students had poor total knowledge level pre the S-PBL strategy application. The findings of the current study were in agreement with **Salah El Dien et al., (2017)**, whose study was entitled "Assessment of nursing care for children undergoing open heart surgery" they found that less than two thirds of the studied nurses (61.3%) had unsatisfactory knowledge regarding open heart surgery. Also The findings of the current study

were in agreement with **Goda et al., (2022)**, whose study was entitled "Assessment of nurses' performance in care of children with critical cardiac conditions", they represented that, less than three quarters of studied nurses had unsatisfactory knowledge.

The researchers in the current study adopted the PBL in the form of brain storming session, debriefing session and continuous feedback which reflected satisfactory knowledge; as most of studied students had good total level of knowledge post S-PBL strategy application. The findings of the current study revealed that, most of the studied students had incompetent level of practice pre the S-PBL strategy application.

The researchers developed a scenario regarding the skills required for caring for children undergoing open heart surgery and timely feedback during the simulation sessions which reflected competent level of practice among most of the studied students post the S-PBL strategy application. The researchers followed a mixed educational strategy based on both the PBL and SBL expecting effective outcomes, the researchers applied the two learning strategies barrel to each other.

From the researchers point of view, it is necessary to develop a well-prepared scenarios that should address all variables affecting the learners' awareness of realism to help effective engagement of students in simulation; improve their ability and the confidence in applying the skills.

Also, from the researchers' point of view; the simulation is a powerful form of purposeful experiences and simulation in cardiac critical care is a crucial as cardiac monitoring devices and equipment requiring high skills learned by simulation training. The researchers viewed that the continuous feedback from the studied students is a crucial point to assure that the provided educational material, the strategy concept and the strategy application also has been understood correctly to have a good out come and to prevent and any overlap in any point during the process pathway.

The findings of the current study were consistent with the results of the quasi-experimental design study done by **Akhu-zaheya et al., (2015)**; students' knowledge acquisition and practice improvement were revealed.

The findings of the current study were in agreement with **Saied, (2017)**, study which was entitled "The impact of simulation on pediatric nursing students, knowledge, self-efficacy, satisfaction, and confidence", identifying human simulation as an effective teaching and learning modality in teaching pediatric nursing students. It was also consistent with **Kiernan, (2018)**, in a study entitled "Evaluating competence and confidence using simulation technology", revealed that the high fidelity simulation enhanced the

nursing students' knowledge and confidence, as simulation labs motivates visual, auditory and tangible learning techniques come in agreement with the finding of the current study.

The researchers followed the S-PBL strategy expecting an effective outcome, and already the studied students' knowledge and practice was improved significantly post the S-PBL strategy application. The findings of the current study were in the same line with **Lim, (2020)** in a study which entitled "Effectiveness of simulation linked problem based learning on nursing college students in South Korea", and reported that adopting the mixed learning strategies both the simulation and problem based learning improves the nursing students' critical thinking disposition and self-efficacy, ensured developing scenarios based on clinical cases variety and operating experience the problem-solving process.

The findings of the current study, also were in the same line with **Tawalbeh, (2020)** in a study which entitled "Effect of simulation modules on Jordanian nursing student knowledge and confidence in performing critical care skills: A randomized controlled trial", it was reported that adding simulation improved the nursing students' confidence and knowledge significantly rather than theoretical and clinical training in performing critical care nursing skills for patients suffering from cardiac, neurological and respiratory health problems.

From the researcher point of view, this might be due to that S-PBL usage was the most effective methods for training the students. Consequently this leads to raised motivation for learning among nursing students, enhanced knowledge acquisition and skills application retention.

The finding of the current study represents that Most of studied student had positive perspective toward barriers of using problem based learning strategy post S-PBL strategy application, compared to most of them had negative perspective pre S-PBL strategy application in relation to barriers regarding problem-based learning e.g. lack of information about PBL and its technique, difficulty in understanding the problem. This result was consistent with the result of a study done by **Kristin et al., (2021)**, entitled "Addressing Barriers to Implementing Problem Based Learning" who revealed that there were several barriers to success problem-based learning.

Also, the result was consistent with the result of the **Othman & Shalaby, (2014)** in a study entitled "Students' Perception and Acceptance of Problem-based Learning Approach in Critical Care Nursing Practice" was conducted at faculty of nursing, Mansoura university, (fourth year under- graduate nursing students of the academic year 2011/2012 (n=209), it was found that, most perceived of the perceived barriers were shortage of time to do

group work (87.5%), heavy work load (81.%) and lack of teaching facilities (71%); less than two thirds (61%) of students perceived their colleagues not committing to their assigned roles and each student focused on his own role only. The latest perceived barriers were the role of teachers change and difficulties to address the key points.

The finding of the current study reveals that, there was a highly statistically significant positive correlation between the studied students' total knowledge score and total practice score pre/post S-PBL strategy application ($P \leq 0.000$). Researchers viewed that, pediatric nurses working in cardiology unit, should understand the pediatric heart diseases including (cardiac anatomy, pathophysiology and significant cardiac diseases) to raise their understanding and providing better effective holistic care to the pediatric patients.

Conclusion:

Based on the results of the present study, it can be concluded that, Simulation linked Problem-based Learning (S-PBL) strategy was effective strategy in improving pediatric students' knowledge as the good total level of knowledge was among minority of studied students pretest, while posttest it was among most of them. Similarly, the S-PBL strategy was effective strategy in improving pediatric students' practice regarding care of children undergoing open heart surgery; most of them had competent level of practice post the S-PBL strategy application.

Most of studied student had positive perspective toward barriers of using problem based learning strategy posttest, compared to minority of them pretest. There was a highly statistically significant positive correlation between the studied students' total knowledge score and total practice score pre/post S-PBL strategy application.

Recommendation:

Based on the findings of the present study: recommend replication of the current study on larger sample size in different setting to achieve wider utilization of the suggested strategy.

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