

Effect of Problem-Based Learning on Problem Solving, Critical Thinking Skills, and Metacognitive Awareness of Critical Care Nursing Students

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ABSTRACT

Context: Problem-based learning should be formally integrated into the curriculum because it enhances students' knowledge, reasoning abilities, and study skills while also supporting the development of clinical reasoning and critical thinking processes.

Aim: This study aimed to evaluate the effect of problem-based learning on problem-solving, critical thinking skills, and metacognitive awareness among critical care nursing students.

Methods: A quasi-experimental design with study and control groups was adopted to accomplish the objective of this study. The study was conducted in the classroom and the nursing skills laboratory at the Technical Institute of Nursing, Cairo University. A Convenience sample included all available students (60 students), divided into two groups of 30, comprising 30 first-year students from the Technical Institute of Nursing, Cairo University. Five tools were used in this study. They are a self-administered questionnaire, the Problem-Solving Process Measurement Scale, the Critical Thinking Disposition (CTD) scale, the Metacognitive Awareness Inventory scale, and the Course Experience Questionnaire (CEQ).

Results: Before applying problem-based learning, there were no statistically significant differences between the control group (n=30) and the study group (n=30) regarding problem-solving skills (66.00 ± 5.53 vs. 66.73 ± 4.58 ; $p=0.516$), critical thinking (49.50 ± 3.60 vs. 51.30 ± 5.76 ; $p=0.139$), metacognitive awareness (81.13 ± 5.05 vs. 81.80 ± 8.01 ; $p=0.677$), or overall skills score (196.63 ± 8.87 vs. 199.83 ± 9.98 ; $p=0.189$). Following the implementation of problem-based learning, the study group demonstrated markedly higher scores than the control group in problem-solving skills (144.76 ± 1.79 vs. 82.00 ± 7.84), critical thinking (130.73 ± 1.89 vs. 74.60 ± 6.61), metacognitive awareness (251.53 ± 3.10 vs. 134.53 ± 10.65), and total skills score (527.03 ± 4.47 vs. 291.13 ± 16.31), with highly statistically significant differences ($p \leq 0.001$).

Conclusion: Problem-based learning positively influences critical care nursing students' problem-solving abilities, critical thinking skills, and metacognitive awareness. It is recommended that problem-based learning be integrated throughout the nursing curriculum, along with providing faculty development programs to enhance educators' competence in applying problem-based learning strategies.

Keywords: Critical care, critical thinking, metacognition, nursing students, problem-based learning

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1. Introduction

Critical care nursing students are trained to deliver advanced care to critically ill patients or those at risk of life-threatening complications. This care is complex, intensive, and continuous. Practitioners must have advanced skills and knowledge of specialized electronic equipment used to monitor and treat acutely ill patients and challenging cases (Gnanadurai, 2021).

Critical care nursing students often face high-risk situations in healthcare. They must be prepared to act as competent professionals and manage critical events effectively. These students should respond calmly and confidently, providing safe, skillful care (Kasemsap, 2021).

Problem-based learning (PBL) is an effective approach for health professional education. Integrating it into the

curriculum helps students build knowledge, strengthen reasoning, improve study skills, and develop cognitive processes for clinical reasoning. In health professional education, PBL organizes knowledge in meaningful, practice-related contexts, promotes critical thinking, supports self-directed learning, and encourages lifelong learning (Choi & Jeon, 2022).

Problem-solving is the process of recognizing and clarifying a problem, exploring its underlying causes, generating possible solutions, ranking them by priority, choosing the most appropriate action, and applying it effectively. Critical thinking (CT), meanwhile, is a continuous and active mental process based on logical reasoning. It enables individuals to examine issues systematically, consider all dimensions of a situation or argument, anticipate complex circumstances, and make

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sound judgments. For nurses, critical thinking involves several essential abilities, including analysis, evaluation, inference, deduction, and induction (Yildirim et al., 2019).

Metacognition is learners' capacity to use previous knowledge to plan strategies for problems. It also involves assessing the results of their actions and adjusting methods when necessary. Metacognition supports learners in reaching their goals by guiding them to select the best strategies for each situation (Abdelrahman, 2020).

Critical care nursing students need to develop personalized problem-solving approaches to respond effectively to patients' complex and advanced healthcare needs. This competence is fundamental for nursing undergraduates, as it enables them to fulfill their professional responsibilities after graduation and to adapt successfully to the ongoing changes in healthcare practice. Accordingly, nursing education should incorporate teaching strategies that strengthen students' problem-solving abilities (Song, 2020).

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2. Significance of the study

Technical diploma nurses are mainly trained in procedural and task-based skills. This focus may limit their ability to apply theory in complex situations. PBL is important because it includes real-life clinical scenarios. It helps students connect theory with practice and improves their clinical readiness (Abdalla, 2026).

The structure of the nursing workforce in Egypt, showed that where diploma- and certificate-prepared nurses represent the largest proportion of nurses, while technical nursing institutes are considered an important pathway for preparing technical-level nurses for healthcare services. Bellizzi et al. reported that nearly 90% of nurses in Egypt hold a certificate or diploma in nursing, while only 6–8% hold a bachelor's degree. Brownie et al., published in the *Eastern Mediterranean Health Journal*, also noted that technical institutes are a major vehicle for preparing technical-level nurses in Egypt (Brownie et al., 2018; Bellizzi, & Padrini, 2021).

Problem-based learning (PBL) is an active teaching strategy. It uses complex, real-world scenarios to help students understand and apply key concepts (Choi & Jeon, 2022). Nursing students, as adult learners, must develop a professional mindset that enables them to think and act like nurses. Their education should help them understand facts, retrieve information, choose interventions, follow procedures, analyze data, interpret findings, and engage in reflection and reasoning (Gnanadurai, 2021).

This study provides important evidence about the value of problem-based learning as a modern approach in critical care nursing education. It shows that learner-centered methods can strengthen core cognitive and reflective skills, especially problem-solving, critical thinking, and

metacognitive awareness. The study also offers nursing educators useful guidance on adding problem-based learning to programs to better prepare students for complex, high-risk clinical situations. Additionally, it considers students' satisfaction with this teaching method. Thus, the study seeks to assess how problem-based learning enhances problem-solving ability, critical thinking skills, and metacognitive awareness among critical care nursing students.

3. Aim of the study

The study aimed to evaluate the effect of problem-based learning on problem-solving, critical thinking skills, and metacognitive awareness among critical care nursing students. This aim was achieved through the following:

- Assess problem-solving, critical thinking skills, and metacognitive awareness of critical care nursing students (pretest).
- Design and implement a problem-based learning strategy for critical care nursing students.
- Evaluate the effect of problem-based learning on problem solving skills level of critical care nursing students (posttest).
- Evaluate the effect of problem-based learning on the critical thinking skills of critical care nursing students (posttest).
- Evaluate the effect of problem-based learning on the metacognitive awareness level of critical care nursing students (posttest).

3.1. Research Hypothesis

- Problem-based learning will have a positive effect on problem solving skills of critical care nursing students in the study group compared to the control group.
- Problem-based learning will have a positive effect on the critical thinking skills of critical care nursing students in the study group compared to the control group.
- Problem-based learning will positively affect the metacognitive awareness of critical care nursing students in the study group compared to the control group.

4. Subjects & Methods

4.1. Research Design

A quasi-experimental design involving study and control groups was employed to fulfill the study objective. The independent variable was the problem-based learning (PBL) teaching strategy, which was applied through the respiratory care unit. The dependent variables were the intervention-related outcomes, namely problem-solving skills, critical thinking skills, and metacognitive awareness. These outcomes were assessed in both the study and control groups before and after the PBL strategy was applied to evaluate its impact.

4.2. Study Setting

The study was conducted in the classroom and the nursing skills laboratory at the Technical Institute of Nursing, Cairo University. It was located on the third floor of the medical education building in the faculty of Medicine at Kasr Al-Ainy and consisted of two classrooms and one nursing skills laboratory.

4.3. Subjects

A convenience sampling method was used to recruit all accessible first-year students enrolled at the Technical Institute of Nursing, Cairo University, during the academic year. The sample included 60 students, who were assigned equally to two groups. Group A consisted of 30 students and served as the control group; they received traditional lecture-based instruction, in addition to routine clinical teaching in the skills laboratory and hospital setting. Group B consisted of 30 students who received problem-based learning instruction and served as the study group.

4.4. Tools and Data Collection

4.4.1. Self-Administered Questionnaire

A researcher-developed questionnaire was prepared after reviewing the relevant literature to assess critical care nursing students' demographic characteristics and knowledge. The questionnaire consisted of five open-ended questions related to students' personal data.

Demographic data: This section was designed to collect information about students' personal and demographic characteristics, including age, gender, total high school grades, and attendance at lectures regarding problem-based learning.

4.4.2. Problem-Solving Skills Assessment Scale

The problem-solving skills assessment scale was adapted from *Lee et al. (2008)*. It was translated into Arabic and then back-translated to ensure consistency. The tool was used to assess critical care nursing students' problem-solving skills before and after the intervention in both groups. It included 30 items rated on a five-point Likert scale and covered five domains: Problem clarification, solution seeking, decision-making, solution implementation, and evaluation and reflection. Responses ranged from 1 to 5, where 1 indicated strongly disagree, 2 indicated disagree, 3 indicated neutral, 4 indicated agree, and 5 indicated strongly agree. The maximum total score was 150, and the results were reported as the mean and standard deviation (SD).

4.4.3. The Critical Thinking Disposition (CTD) Scale

This scale was adopted from *Yoon (2004)* and translated into Arabic to measure the levels of critical thinking skills of critical care nursing students in the pre- and post-test for two groups. The scale comprises 27 items rated on a 5-point Likert scale and grouped into 7 domains: Confidence, eagerness, fairness, objectivity, prudence, skepticism, and systematicity. Each item is scored from 1 to 5, where 1 represents strongly disagree, 2 disagree, 3 neutral, 4 agree, and 5 strongly agree. Some items or subscales are reverse-scored, with scores ranging from 1 (strongly agree) to 5 (strongly disagree). The maximum total score is 135, and the findings are reported as the mean and standard deviation.

4.4.4. The Metacognitive Awareness Inventory Scale

It was adopted from *Schraw and Sperling-Dennison, (1994)*, and translated into Arabic to measure the critical care nursing students' metacognitive awareness levels in the pre- and post-test for two groups. It is composed of 52 items that

measure different dimensions of metacognition. It is based on a 5-point Likert scale, and is distributed across eight domains (Declarative knowledge, procedural knowledge, conditional knowledge, planning, information management strategies, comprehension monitoring, debugging strategies and evaluation). Each scale statement is evaluated against 5 points, ranging from (strongly disagree = 1, disagree = 2, neither = 3, agree = 4, and strongly agree = 5). The overall total score was 260, that are calculated and presented as mean and SD.

4.5. Procedures

The operational design included four main components: The preparatory phase, assessment of tools' validity and reliability, pilot study, and fieldwork.

Preparatory phase: This phase involved reviewing recent relevant literature and theoretical information related to the study topic. Sources such as textbooks, research articles, online periodicals, and scientific journals were used to guide the selection and development of the data collection tools.

Validity and reliability: The validity of the developed tools was assessed through face and content validity. The tools were reviewed by a panel of seven experts from the Medical-Surgical Nursing Department, Faculty of Nursing, Ain Shams University, including three professors and four assistant professors. The experts evaluated the tools for clarity, relevance, comprehensiveness, simplicity, and applicability. Based on their feedback, minor revisions were made, and the final versions of the tools were prepared.

The reliability of the developed tools was assessed statistically using Cronbach's alpha. Cronbach's Alpha coefficients for students' Problem-Solving Skills Measurement Scale was 0.715, Critical Thinking Disposition (CTD) scale was 0.806, and the Metacognitive Awareness Inventory scale was 0.60.

A pilot study was conducted with 10% of the sample (six students) to assess the clarity, applicability, and efficiency of the study tools, as well as the feasibility of carrying out the research procedures. The students who participated in the pilot study were included in the final study sample because no changes were needed after the pilot testing.

Fieldwork: The study was implemented after obtaining the ethical approval was also obtained from the Faculty of Nursing, Ain Shams University. Official approval through formal letters submitted to the director of the Technical Institute of Nursing, Cairo University, to permit with data collection. The study's aim, objectives, and expected implications were explained to the participating students. Verbal consent was obtained after informing them that participation was voluntary, that they had the right to refuse participation, and that they could withdraw at any time without providing a reason. The pre-test and post-test scores were used only for research purposes and were not included in students' academic course grades.

The fieldwork was completed through consecutive phases, including preparation, implementation, and evaluation, to assess the effect of problem-based learning on problem-solving skills, critical thinking skills, and metacognitive awareness among critical care nursing students.

Preparation phase: The educational module regarding care of patients with respiratory alterations were designed. Problem-based learning scenarios was designed to address the core areas of respiratory care that aimed to:

- Enhance students' clinical reasoning and decision-making skills.
- Improve problem-solving abilities in respiratory care situations.
- Develop critical thinking and reflective learning.
- Strengthen metacognitive awareness during clinical practice.

Problem-based learning scenarios were developed based on real or simulated clinical situations. Clinical teaching sessions were carefully planned following the PBL cycle: Presentation of the clinical problem; group discussion and identification of prior knowledge; identification of learning objectives; self-directed learning; group discussion of findings, reflection; and feedback. A variety of teaching strategies and media were used to support learning, including small-group discussions for collaborative learning, PowerPoint presentations for structured content delivery, case study handouts, and clinical worksheets. These methods were selected to enhance engagement, active participation, and clinical reasoning skills. The instructor acted as a facilitator, guiding learning rather than providing direct answers.

Implementation phase: The pre-student assessment was done for the entire number of critical care nursing students (60 students) at the beginning of the second semester of the academic year. The assessment included a baseline assessment of students' problem-solving skills, critical thinking skills' level, and a metacognitive awareness.

Participants were assigned to two groups: Group A served as the control group, and Group B served as the study group. For group A, the lectures were delivered in the classroom using traditional lecture and clinical teaching, and for group B, problem-based learning was used. Five case scenarios were designed to apply the problem-based learning method that align with the learning objectives. It included five case scenarios for caring for patients with Pneumonia, Chronic Obstructive Pulmonary Disease (COPD), Adult Respiratory Distress Syndrome (ARDS), Pneumothorax, and asthma.

The students answered the pre-test a week before the beginning of the course in about 30-45 minutes to have the baseline assessment to be compared with the post-test administered after the implementation of the problem-based learning method and the lecture. The problem-solving skills measurement scale, the critical thinking disposition scale, and the Metacognitive Awareness Inventory scale were completed by students, who took approximately 15 minutes each.

Evaluation phases: Group A (lecture) and Group B (problem-based learning) completed the post-test after implementing the two teaching methods; the control group (lecture) and the study group (problem-based learning) completed the post-test in end of the second semester of

academic year. The evaluation was done as a posttest by the same tools used in the pretest.

4.6. Data analysis

Data were organized, summarized, and displayed using descriptive statistics. Quantitative results were presented as means and standard deviations, while qualitative data were reported as frequencies and percentages. Statistical analysis was performed using SPSS version 28. The student's t-test was used to compare quantitative variables between two groups. Statistical significance was interpreted as follows: $p > 0.05$ indicated no significant difference, $p \leq 0.05$ indicated a statistically significant difference, and $p \leq 0.001$ indicated a highly statistically significant difference.

5. Results

Table 1 presents a comparison of demographic characteristics of the participants in the two studied groups: The control and study groups.; it reveals that the mean age of the control group and study group were 19.1 ± 0.61 and 19.50 ± 0.90 , respectively. The mean total number of high school graduates in the control and study groups was 75.46 ± 7.37 and 74.01 ± 6.65 , respectively. 60% of the control group were females, 56.7% were from rural areas, and 100% did not attend lectures on problem-based learning. While 36.7% of the study group were females, 63.3% were from rural areas, and 100% did not attend lectures on problem-based learning; there was no statistically significant difference between the two groups for gender, residence, or attendance to problem-based learning training.

Table 2 shows no statistically significant difference between the control and study groups during the pre-test for any of the problem-solving skills ($p > 0.05$).

Table 3 shows highly statistically significant differences between the control and study groups at the post-test for all problem-solving skills ($p \leq 0.001$).

Table 4 shows no statistically significant difference between the control and study groups during the pre-test for all critical thinking skills ($p > 0.05$).

Table 5 shows highly statistically significant differences between the control and study groups at the post-test for all critical thinking skills ($p \leq 0.001$).

Table 6 shows no statistically significant difference between the control and study groups during the pre-test for all metacognitive awareness skills ($p > 0.05$).

Table 7 reveals highly statistically significant differences between the control and study groups during the post-test for all metacognitive awareness skills after the implementation of problem-based learning ($p \leq 0.001$).

Table 8 shows no statistically significant difference between the control and study groups during the pre-test in total scores for problem solving, critical thinking, metacognitive, and total skills ($p > 0.05$).

Table 9 displays highly statistically significant differences between the control and study groups during the post-test for total score of problem solving, critical thinking skills, metacognitive awareness, and total skills ($p \leq 0.001$).

Table (1): Comparison of study and control group demographic characteristics of the studied nursing students (n=60).

Variables	Control Group (n=30)		Study Group (n=30)		t-test	p-value
	No.	%	N	%		
Age						
18 years	4	13.3	2	6.7		
19 years	19	63.3	17	56.7		
20 years	7	23.3	5	16.7		
21 years	0	0.0	6	20.0		
Mean±SD	19.1±0.61		19.50±0.90		15.21	0.000
Total high school grades						
Mean±SD	75.46 ± 7.37		74.01± 6.65		60.99	0.000
Gender					X²	
Male	12	40.0	19	63.3	0.215	0.064
Female	18	60.0	11	36.7		
Residence						
Rural	17	56.7	19	63.3	0.234	0.087
Urban	13	43.3	11	36.7		
Attendance lectures regarding problem-based learning						
Yes	30	0.0	30	0.0	0.889	0.234
No	30	100.0	30	100.0		

Table (2): Comparison of problem-solving skills between study and control groups before the implementation of problem-based learning (n= 60).

Problem solving skills	No. of items	Control Group (n=30)		Study Group (n=30)		t-test	p-value
		Mean±SD	Mean±SD	Mean±SD	Mean±SD		
Clarifying problem	6	12.43 ± 2.72	12.70 ± 1.15	0.486	0.631		
Seeking solution	6	12.56 ± 1.99	12.93 ± 1.52	0.791	0.435		
Decision making	6	13.768 ± 3.18	13.90 ± 1.70	0.217	0.830		
Applying the solution	6	13.83 ± 2.99	13.73 ± 2.91	0.172	0.864		
Evaluation & reflection	6	13.40 ± 2.40	13.46 ± 1.50	0.141	0.889		

Table (3): Comparison of problem-solving skills between study and control groups after the implementation of problem-based learning (n= 60).

Problem solving skills	No. of items	Control Group (n=30)		Study Group (n=30)		t-test	p-value
		Mean±SD	Mean±SD	Mean±SD	Mean±SD		
Clarifying problem	6	16.16 ± 3.05	28.23 ± 1.07	19.96	0.000		
Seeking solution	6	15.96 ± 3.55	29.27 ± 0.86	19.46	0.000		
Decision making	6	16.73 ± 3.92	28.90 ± 0.66	17.50	0.000		
Applying the solution	6	18.20 ± 3.67	29.20 ± 0.71	16.26	0.000		
Evaluation & reflection	6	14.93 ± 3.25	29.16 ± 0.79	22.85	0.000		

Table (4): Comparison of critical thinking skills between study and control groups before the implementation of problem-based learning (n= 60).

Critical thinking skills	No. of items	Control Group (n=30)		Study Group (n=30)		t-test	p-value
		Mean±SD	Mean±SD	Mean±SD	Mean±SD		
Confidence	4	6.43 ± 1.25	6.23 ± 1.55	0.560	0.579		
Eager	5	9.56 ± 1.90	10.43 ± 1.92	1.726	0.095		
Fairness	4	8.56 ± 2.32	8.63 ± 1.97	0.119	0.906		
Objectivity	3	6.30 ± 1.91	6.58 ± 1.77	0.571	0.573		
Prudence	4	6.43 ± 1.56	6.36 ± 1.84	0.189	0.851		
Skepticism	4	6.00 ± 1.85	6.43 ± 2.06	1.160	0.255		
Systematicity	3	6.20 ± 1.62	6.63 ± 1.65	1.28	0.210		

Table (5): Comparison of critical thinking skills between study and control groups after the implementation of problem-based learning (n= 60).

Critical thinking skills	No. of items	Control Group	Study Group	t-test	p-value
		(n=30)	(n=30)		
		Mean±SD	Mean±SD		
Confidence	4	10.10 ± 2.79	19.43 ± 0.72	17.82	0.000
Eager	5	12.93 ± 3.49	24.30 ± 0.70	18.05	0.000
Fairness	4	11.23 ± 2.45	19.43 ± 0.84	17.51	0.000
Objectivity	3	8.20 ± 2.34	14.63 ± 0.15	14.41	0.000
Prudence	4	12.36 ± 2.48	19.16 ± 0.87	13.68	0.000
Skepticism	4	11.73 ± 2.21	19.13 ± 1.01	17.75	0.000
Systematicity	3	8.03 ± 1.67	14.63 ± 0.56	19.74	0.000

Table (6): Comparison of metacognitive awareness between study and control groups before the implementation of problem-based learning (n= 60).

Awareness elements	No. of items	Control Group	Study Group	t-test	p-value
		(n=30)	(n=30)		
		Mean±SD	Mean±SD		
Declarative knowledge	8	11.50 ± 2.35	11.86 ± 2.84	0.543	0.591
Procedural knowledge	4	7.60 ± 1.42	7.36 ± 1.65	0.728	0.472
Conditional knowledge	5	8.56 ± 2.32	8.48 ± 1.52	0.184	0.855
Planning	7	10.90 ± 1.64	11.03 ± 2.53	0.229	0.821
Information management strategies	10	14.66 ± 1.26	14.43 ± 4.63	0.272	0.788
Comprehension monitoring	7	10.03 ± 1.40	10.56 ± 1.81	1.53	0.136
Debugging strategies	5	7.76 ± 1.50	8.43 ± 1.83	1.88	0.069
Evaluation	6	10.10 ± 2.15	9.63 ± 1.54	1.18	0.247

Table (7): Comparison of metacognitive awareness skills between study and control groups after the implementation of problem-based learning (n= 60).

Awareness elements	No. of items	Control Group	Study Group	t-test	p-value
		(n=30)	(n=30)		
		Mean±SD	Mean±SD		
Declarative knowledge	8	20.93 ± 3.49	38.40 ± 0.96	27.17	0.000
Procedural knowledge	4	10.93 ± 2.21	19.10 ± 0.95	18.35	0.000
Conditional knowledge	5	13.66 ± 2.80	23.86 ± 0.86	21.78	0.000
Planning	7	20.33 ± 3.13	33.70 ± 1.11	23.11	0.000
Information management strategies	10	25.03 ± 3.93	48.40 ± 1.32	29.10	0.000
Comprehension monitoring	7	17.10 ± 3.74	34.40 ± 0.93	25.37	0.000
Debugging strategies	5	11.70 ± 1.93	24.43 ± 0.81	31.75	0.000
Evaluation	6	14.83 ± 2.99	29.23 ± 0.89	27.12	0.000

Table (8): Comparison of total score of the problem solving, critical thinking, and metacognitive awareness of study and control groups before the implementation of problem-based learning (n= 60).

Overall skills	No. of items	Control Group	Study Group	t-test	p-value
		(n=30)	(n=30)		
		Mean±SD	Mean±SD		
Problem solving	30	66.00 ± 5.53	66.73 ± 4.58	0.658	0.516
Critical thinking	27	49.50 ± 3.60	51.30 ± 5.76	1.52	0.139
Metacognitive	52	81.13 ± 5.05	81.80 ± 8.01	0.421	0.677
Total skills	109	196.63 ± 8.87	199.83 ± 9.98	1.34	0.189

Table (9): Comparison of the total mean score of problem solving, critical thinking, and metacognitive awareness of study and control groups after the implementation of problem-based learning (n= 60).

Overall skills	No. of items	Control Group	Study Group	t-test	p-value
		(n=30)	(n=30)		
		Mean±SD	Mean±SD		
Problem solving	30	82.00 ± 7.84	144.76 ± 1.79	45.46	0.000
Critical thinking	27	74.60 ± 6.61	130.73 ± 1.89	44.164	0.000
Metacognitive	52	134.53 ± 10.65	251.53 ± 3.10	56.76	0.000
Total skills	109	291.13±16.31	527.03±4.47	77.21	0.000

6. Discussion

Nursing students need to develop problem-based nursing skills before entering clinical practice to meet patients' growing healthcare needs and enhance their future professional competence. Problem-based learning supports this preparation through realistic clinical situations and simulation-based scenarios that help students integrate knowledge, strengthen clinical reasoning, and achieve the intended educational outcomes (Kousar & Afzal, 2020). Therefore, this study was conducted to evaluate the effect of problem-based learning on problem-solving, critical thinking skills, and metacognitive awareness among critical care nursing students.

Regarding the demographic profile of the control and study groups, the findings of the present study show that the participants' mean age was 19.1 ± 0.61 years in the control group and 19.50 ± 0.90 years in the study group, which is the common mean age of the first-year students in any faculty in Egypt, indicating that age is relatively consistent between the two groups. This homogeneity is beneficial because it reduces the likelihood that age-related factors will introduce bias into the study's outcomes, ensuring that both groups are comparable in terms of this important demographic variable.

These results differ from those of Choi and Jeon (2022), who examined the determinants of nursing students' problem-solving competency, in which the mean ages of the control and study groups were 21.56 ± 1.99 and 20.43 ± 1.29 years, respectively, with no significant difference between the groups. In contrast, this finding does not align with Kousar and Afzal, (2020), who investigated how problem-based learning influences midwifery students' critical thinking and problem-solving abilities and stated that the mean age of participants (control and study group) was 22.38 ± 1.18 .

Similarly, a statistically significant difference in total high school grades was observed between the control group and the study group, although the mean difference was relatively small. This suggests that academic performance prior to entering the nursing study was almost equivalent between the two groups, further strengthening the reliability of any conclusions drawn. This finding differs from that of Mohamed et al. (2019), who explored nursing students' views regarding metacognitive competence, self-regulation, and the use of problem-based learning. Their study found that more than one-third of the students achieved very good grades, while fewer than one-quarter achieved good grades. Contrariwise, this finding is at odds with Kousar and Afzal,

(2020), who reported a mean academic score of 735.19 ± 84.871 .

Regarding gender distribution, no statistically significant difference was found between the control and study groups. In the control group, nearly two-thirds of participants were females, while in the study group, more than one-third were females. The relatively high proportion of male students, representing two-fifths of the control group and nearly two-thirds of the study group, may reflect recent cultural changes in Egypt. In the past, nursing education in Egyptian universities was largely limited to females, whereas male enrollment has become more accepted in recent years. Although this difference in gender distribution may seem substantial, the non-statistically significant differences suggest that this variation did not have a meaningful impact on the study's outcomes. This could imply that gender, in this context, is not a critical variable influencing the intervention's effectiveness or the outcomes being measured.

This finding is inconsistent with Alaagib (2019), who compared problem-based and traditional lectures in physiology teaching in Sudan and found that more than half of the participating students were females. However, it aligns with Arli et al. (2017), who examined critical thinking and caring among nursing students and reported that males accounted for more than half of the sample.

Additionally, most participants in both groups were from rural areas. In the control group, nearly three-fifths of participants were from rural areas, compared to about two-thirds in the study group. However, this difference was not statistically significant, indicating that both groups were comparable in terms of geographic background and that residence did not influence the study outcomes. This similarity across residence locations helps ensure that the two groups had relatively comparable socio-environmental influences, further validating their comparability. Conversely, this result is consistent with El-Shaar and Gaber (2014), who investigated the effect of problem-based learning on students' critical thinking dispositions, knowledge acquisition, and knowledge retention, and stated that more than half of the control group were from rural areas, and about two-thirds of the experimental group were from rural areas.

Regarding training and lecture attendance on problem-based learning (PBL): One notable commonality between the two groups is that none of the participants in either the control or the study group had attended any prior lectures or

training on PBL. This finding is critical because it ensures that both groups started from a similar baseline in terms of knowledge and exposure to PBL. The lack of prior exposure to PBL across both groups eliminates potential bias arising from pre-existing knowledge, ensuring that any observed differences in outcomes are likely due to the intervention or study design rather than prior experience with the subject matter.

The non-significant differences between the two groups regarding gender, residence, and previous attendance of training on problem-based learning indicate that the groups were comparable in these characteristics. This comparability supports the internal validity of the study by reducing the likelihood that these baseline variables influenced or confounded the study outcomes. The similar demographic characteristics between the control and study groups allow for a more accurate comparison of outcomes, making it easier to attribute any observed differences to the intervention rather than to demographic disparities.

This finding is consistent with *Salari et al. (2018)*, who compared pure problem-based learning, hybrid problem-based learning, and traditional lecturing in terms of their effectiveness in developing undergraduate pediatric nursing students' cognitive skills and noted that most of the control and study groups did not attend any problem-based learning courses.

Regarding nursing students' pre- and post-test problem-solving skills, the current study shows no statistically significant difference between the control and study groups before the implementation of PBL. Both groups had similar scores in all problem-solving skills, including clarifying the problem, seeking solutions, decision-making, applying the solution, and evaluating and reflecting. This indicates that both groups started with comparable levels of problem-solving abilities, ensuring that any observed changes post-intervention can be attributed to the PBL strategy.

A recent study by *Wosinski et al. (2018)* supports this finding, indicating that baseline problem-solving skills across groups are typically similar before an intervention because such skills often require targeted instruction, such as PBL, to develop effectively. However, *Ramadoni and Chien (2023)* found baseline differences in a study of nursing students, attributing them to prior exposure to problem-based learning in informal settings, which could create variance before the formal introduction of PBL.

Following the application of problem-based learning, the present study shows highly statistically significant difference in problem-solving skills between the study group and the control group. The study group demonstrated a higher mean score across all problem-solving domains, including problem clarification, solution seeking, decision-making, solution implementation, evaluation, and reflection, with substantially higher mean scores than the control group. These results supported the first research hypothesis.

This finding agrees with *Rahim et al. (2024)*, who found that PBL significantly improved problem-solving skills among medical and nursing students by fostering a deeper understanding of clinical cases and encouraging independent learning. Similarly, *Lee et al. (2020)* reported that PBL enhances critical thinking and problem-solving abilities through active engagement with realistic scenarios.

Conversely, *Trullàs et al. (2022)* argue that while PBL has a positive impact, the level of improvement can be influenced by the length of the intervention and student engagement, with shorter interventions showing less pronounced effects.

The findings of the present study indicates that, before the application of problem-based learning, there were no statistically significant differences between the control and study groups in relation to critical thinking skills, as evidenced by similar scores across variables such as confidence, eagerness, fairness, objectivity, prudence, skepticism, and systematicity. This finding indicates that both groups started with comparable levels of critical thinking ability.

This finding is consistent with *Gleeson et al. (2021)* observed that, before an intervention, groups tend to have similar levels of critical thinking, as these skills generally require structured development over time. However, *Yuan et al (2008a)* found slight differences in baseline critical thinking skills in their study, suggesting that prior educational experiences or informal exposure to critical thinking tasks can create some variation among students before PBL implementation.

The present study reveals highly significant differences in the critical thinking skills of the study group compared to the control group after PBL. Across all variables—including confidence, eagerness, fairness, objectivity, prudence, skepticism, and systematicity. The study group shows substantial gains, with mean scores that were statistically significantly much higher than those of the control group. These findings supported the second research hypothesis.

These results are consistent with findings from *Shin and Kim (2013)*, who found that PBL led to notable gains in critical thinking by encouraging students to analyze complex problems and reflect on their reasoning processes. Similarly, *Sharma et al. (2023)* reported that nursing students who participated in PBL developed stronger critical thinking skills compared to those in traditional learning environments. However, *Yang and Yang, (2013)* highlight that improvements in critical thinking can vary depending on the facilitation of the PBL process, suggesting that the instructor's role is key to optimizing learning outcomes.

The present study reveals no statistically significant differences in metacognitive awareness between the control and study groups before PBL implementation. Both groups had comparable scores in all metacognitive subscales, namely declarative knowledge, procedural knowledge, conditional knowledge, planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation.

Millanzi and Kibusi (2020) support this finding, stating that students often show similar levels of metacognitive skills at baseline because these skills are not commonly emphasized in traditional teaching methods. However, *Seleem et al. (2026)* noted that certain students may display higher baseline metacognitive skills if they have prior exposure to reflective learning practices, leading to initial variations in pre-test results.

Following the implementation of PBL, the current findings highlight highly statistically significant differences between the two group's metacognitive awareness across all areas. The metacognitive awareness, namely declarative

knowledge, procedural knowledge, conditional knowledge, planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation, demonstrated considerable improvement in the study group compared with the control group. This enhancement may be related to the application of Problem-Based Learning (PBL), which encourages students to actively regulate, monitor, and evaluate their own learning processes. This approach engages students in active problem-solving, encourages reflection, and supports self-regulation through structured learning activities. Additionally, the collaborative nature of PBL and the use of diverse learning resources may have enhanced students' ability to monitor and evaluate their own thinking. These factors likely contributed to the observed enhancement in metacognitive skills among the study group. These findings supported the third research hypothesis.

These results align with the study by *Aliazas et al. (2024)*, which found that PBL significantly improved students' metacognitive awareness by encouraging self-regulation, planning, and reflection on learning strategies. Similarly, *Gholami et al. (2021)* reported that PBL helped students develop higher levels of metacognitive skills, particularly in areas like comprehension monitoring and planning. However, *Choi, (2004)* suggest that while PBL is effective, the gains in metacognitive awareness may depend on the extent to which students are encouraged to engage in self-directed learning and reflection, with more structured PBL environments showing better results.

The findings of the present study show highly statistically significant differences between the control and study groups after the application of problem-based learning across total problem-solving scores, critical thinking scores, metacognitive awareness scores, and overall skills scores. In contrast, no statistically significant differences were observed between the two groups before PBL implementation. This difference between the two studied group after PBL implementation may be explained by the nature of problem-based learning as a student-centered teaching strategy that promotes active learning, stimulates critical thinking, strengthens students' ability to manage their own learning, and develops metacognitive and overall cognitive skills.

In line with the present study, *Son (2020)* examined the effect of simulation-based problem-based learning in a maternity nursing clinical practicum on nursing students' learning attitudes, metacognition, and critical thinking, using a quasi-experimental design. Son's findings revealed that students in the experimental group, who participated in S-PBL, experienced significant improvements in learning attitude and critical thinking when compared to the control group ($p < 0.01$). This contrasts with the control group, in which no significant changes in learning attitude, metacognition, or critical thinking were observed between the pre- and post-test assessments. The study demonstrated that S-PBL is an effective strategy for enhancing nursing students' critical thinking and learning transfer by providing practical, scenario-based experiences, aligning with the current study's results in supporting the positive impact of problem-based learning approaches on student outcomes.

Likewise, *Gholami et al. (2016)* evaluated the impact of problem-based learning compared with conventional lecture-based teaching on enhancing nursing students' critical thinking skills and metacognitive awareness. Their findings demonstrated that the lecture-based approach did not produce any significant improvement in students' critical thinking or metacognitive levels, indicating its limited role in fostering higher-order cognitive abilities. In contrast, implementing PBL resulted in a statistically significant improvement in overall critical thinking scores ($p < 0.01$). More specifically, significant improvements were observed in key sub-skills such as evaluation and deduction ($p < 0.05$), reflecting students' improved ability to assess evidence critically and draw logical conclusions. These findings highlight the effectiveness of PBL in promoting deeper cognitive engagement and analytical thinking. These results are consistent with the current study and support the view that active, student-centered learning approaches are more effective than traditional methods for developing essential cognitive and metacognitive competencies in nursing education.

Yuan et al. (2008b) investigated the role of problem-based learning in improving nursing students' critical thinking skills in the People's Republic of China using a quasi-experimental design. Their findings indicated no significant difference in critical thinking skills between the groups at the pretest stage. However, significant differences were found at the post-test between students taught through problem-based learning and those taught by lectures. Students in the problem-based learning group showed greater improvement in the overall California Critical Thinking Skills Test scores, particularly in the analysis and induction subscales, compared with students in the lecture group. These results suggest that problem-based learning helped enhance nursing students' critical thinking skills.

Schaller et al. (2023) found that integrating problem-based learning with the flipped classroom approach improved students' theoretical knowledge and clinical skills, especially among students without previous clinical experience. Students in the PBL-flipped classroom group achieved higher theoretical scores than those taught traditionally. Inexperienced students also performed better in clinical skills after receiving the combined approach. However, students with prior clinical experience showed better practical performance with traditional teaching. Overall, the study suggested that the PBL-flipped classroom method is particularly useful for beginners in clinical training.

7. Conclusion

In summary, the current study's findings indicated that problem-based learning positively influenced critical care nursing students' problem-solving abilities, critical thinking skills, and metacognitive awareness. Accordingly, the research hypothesis was supported.

8. Recommendation

According to the findings of this study, the following recommendations are proposed:

- Problem-Based Learning (PBL) should be adopted as an effective teaching strategy in critical care nursing

education to improve students' problem-solving skills, critical thinking, and metacognitive awareness.

- Nursing curricula should incorporate structured PBL activities, especially in courses that require clinical reasoning and decision-making.
- Planning training programs to improve nursing teachers' practice in using problem-based learning in their teaching avenue.
- Nursing educators should be trained on the proper design and implementation of PBL to maximize its effectiveness.
- Active, student-centered learning approaches should be encouraged to enhance students' engagement and self-directed learning.
- Continuous evaluation of students' cognitive and metacognitive skills should be conducted to ensure the effectiveness of PBL.
- Further research is recommended to examine the long-term effects of PBL on clinical performance and its applicability in different nursing specialties.
- Replication of the same study on a larger probability sample across different geographical locations to improve data generalizability.

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