Original Article

Comparison of the effects of smartphone-based applications and inquiry-based learning on self-efficacy in clinical performance of undergraduate nursing students in the neonatal intensive care unit

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Abstract

Background & Objective: The increased use of electronic resources in education has necessitated the transformation of traditional teaching methods into modern educational technologies. The present study aimed to compare the effects of inquiry-based learning (IBL) and smartphone-based application learning (SBAL) on clinical performance self-efficacy (CPSE) of undergraduate nursing students in the neonatal intensive care unit (NICU).

Materials & Methods: This quasi-experimental study was conducted at the NICU of Urmia University of Medical Sciences in Urmia, Iran, between September 2020 and February 2021. A convenience sampling method was used to select 64 undergraduate nursing students who were assigned to three groups. The SBAL group (n=21) and the IBL group (n=22) received six training sessions (60 minutes each session) along with conventional clinical education, while the control group (n=21) received conventional clinical education. All groups completed the CPSE scale before and after their internship. Data were analyzed in SPSS software (version 24) using statistical tests, including Chi-square, paired t-test, ANOVA, Kruskal-Wallis, and Bonferroni multiple comparisons. A p-value of less than 0.05 was considered statistically significant.

Results: The mean increase in the total CPSE score was significantly different among the three groups (P<0.001). The SBAL (P<0.001) and IBL (P<0.001) groups demonstrated a more marked increase in the CPSE score compared to the control group. In addition, the increase in scores in all CPSE domains was higher in the intervention groups trained by SBAL (P<0.001) and IBL (P<0.01) compared to the control group. Nonetheless, there was no significant difference in the increase in CPSE scores between the SBAL and IBL groups (P>0.05).

Conclusion: The findings of this study suggested that both SBAL and IBL can enhance the CPSE of nursing students undergoing conventional clinical training. Nevertheless, no significant difference was observed between the two methods in terms of improving the self-efficacy of clinical performance. Future studies with larger sample sizes are recommended to compare the effectiveness of these methods.

Keywords: inquiry-based learning, nursing students, nursing process, self-efficacy, smartphone-based application

Introduction

Nursing students' practical experience and the integration of all learned clinical skills are essential components of internships or practicum courses in nursing bachelor programs. These experiences serve as a crucial link between academic education and a professional career (1). Medical universities are responsible for equipping students with the necessary capabilities to prevent, treat, and promote community health (2). While conventional clinical education has been the oldest and most commonly used model of

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clinical nursing education (3), the healthcare industry is constantly evolving, and there is a growing need for innovative and effective teaching methods to enhance the clinical education of nursing students and better prepare them for their professional careers. Therefore, exploring and evaluating new approaches to clinical education is imperative to ensure that nursing students receive the best possible training.

It is crucial to empower students to apply what they have learned during their education in practical settings. As a result, clinical performance in students, particularly during internships, is a significant concern among clinical nurse educators (4). Bandura's self-efficacy theory is one of the theories used to measure the levels of self-efficacy in students regarding their clinical skills (5). According to Bandura (1977), Self-efficacy refers to an individual's belief in his/her capacity to execute behaviors necessary to produce specific performance attainments (6). In the field of clinical education, clinical performance self-efficacy (CPSE) reflects students' beliefs about their ability to perform their duties and tasks, promoting their efforts and perseverance in studying and learning nursing concepts and skills (7). Therefore, the enhancement of students' CPSE is crucial for ensuring their success in clinical settings and their ability to provide high-quality care to patients.

Studies conducted among different nursing faculties in Iran have illustrated that the levels of CPSE among nursing students vary between low (8) and medium levels (9). Specifically, nursing students in Rasht have been found to demonstrate low levels of performance in evaluations, nursing diagnosis, and implementation of nursing care (8).

The CPSE can significantly impact individuals' ability to provide independent care for patients. The importance of self-efficacy in clinical settings is closely linked to its impact on future performance (10). Therefore, it is crucial to implement standards to improve the quality of nursing care (11), including processes aimed at identifying patients' health status, current health problems, or potential healthcare challenges (12). Despite the global understanding of the nursing process and its legality in most countries, there are still challenges in its implementation, particularly the inadequate training provided to students regarding the nursing process and its application in clinical settings (13). This highlights the need for nursing education programs to prioritize training in the nursing process to ensure that students are adequately prepared to provide high-quality care in clinical settings.

Rajabpoor et al. (2018) reported that 93.5% of nursing students identified the lack of principal training in the nursing process during their studentship as the most significant barrier to its implementation (13). This finding indicates that inadequate practical and clinical training can result in fewer positive outcomes in terms of translating theoretical knowledge presented in classrooms into credible abilities in clinical settings (14). The improvement of nursing students' clinical self-efficacy and skills through the application of new tools has become an essential factor in nursing education systems. It is considered pivotal to base these tools on the philosophy of student-centered learning approaches with a nursing theoretical framework (15). Learner-centered and interactive learning can be effectively implemented through the development of web-based instruction (16). The first steps towards utilizing diverse electronic resources were taken in the United States in the 1870s. In Iran, distance education was established in 1971 with the Correspondence Faculty at Abu Reyhan Biruni University (17). The rise of smartphones and their ability to run software programs has made them an accessible electronic learning tool (18). The advantages of smartphone technology in nursing education have been investigated in various studies using surveys, as well as qualitative and quantitative research methods (18-20).

John Dewey introduced the first inquiry-based (exploratory) learning (IBL) method in the United States in the 1960s (21). In the IBL method, the focus is not solely on what learners learn but also on how they learn, like a nurse. The IBL puts an emphasis on active participation and encourages students' responsibility in discovering knowledge based on real-world clinical experiences, leading to the development of self-directed and group-initiated learning (22). A wide array of studies have highlighted the effectiveness of IBL in learning evidence-based nursing practice competencies (23) and improving students' conceptualization of the problem space (24).

Nursing students need to acquire the skills to work in pediatric and neonatal units, including children's growth and development, diagnosis of common pediatric diseases, treatment measures, and related nursing care services (25). Furthermore, nursing education should be purposefully implemented to enhance students' clinical competence, develop decision-making skills in cases of anxiety, and promote the application of the nursing process in clinical settings to bridge the gap between theory and practice at the bedside (13). Clinical nurse teachers face the challenge of preparing proficient and

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competent nursing students within a limited orientation time in the NICU (26).

In addition to preparing students for acute care settings, clinical nurse teachers must also adopt innovative clinical teaching approaches (27). Smartphone-based mobile education, as a location-based information and self-directed learning tool, is a useful method for repetitive learning of specific knowledge and skills without limitations (19). Furthermore, Theobald and Ramsbotham (2019) emphasized that the IBL approach facilitates students' clinical reasoning and helps them to "think like a nurse" (22). Therefore, the present study aimed to compare the effects of smartphone-based application learning (SBAL) and IBL with conventional clinical education on clinical self-efficacy among undergraduate nursing students working in NICUs affiliated with Urmia University of Medical Sciences, Urmia, Iran.

Materials & Methods

Design and setting(s)

From September 2020 to February 2021, a quasi-experimental study was conducted on 64 sixth-semester undergraduate nursing students at Urmia University of Medical Sciences, Urmia, Iran.

Participants and sampling

The statistical population included students in the sixth semester of the Bachelor of Nursing program. Clinical education at the School of Nursing and Midwifery was conducted according to the routine confirmed by the Director of Clinical Affairs in all consecutive semesters, without the researcher's intervention. Based on the educational planning at the university, each semester had between 29-35 students, with a maximum of six students in each internship group. To prevent information transfer, the first two groups of each semester were designated as control groups, while the subsequent groups were assigned as intervention groups (Figure 1). Therefore, out of the 64 students (all students of the two semesters), 21 students were assigned to the control group, 21 students were placed in the IBL group, and 22 students were selected for the SBAL group. The sample size in each group was sufficient to compare the mean values, considering a significance level of 0.05, a power of 80%, and an effect size of 0.4.

The inclusion criteria were as follows: willingness to participate in the study, completing the pediatric nursing care course (PNCC), enrolment in the Healthy and Sick Pediatrics Nursing Internship, and enrolment in the Healthy and Sick Pediatrics Nursing Internship courses during the current semester. On the other hand, the exclusion criteria entailed unwillingness to participate in the study and partial completion of questionnaires.

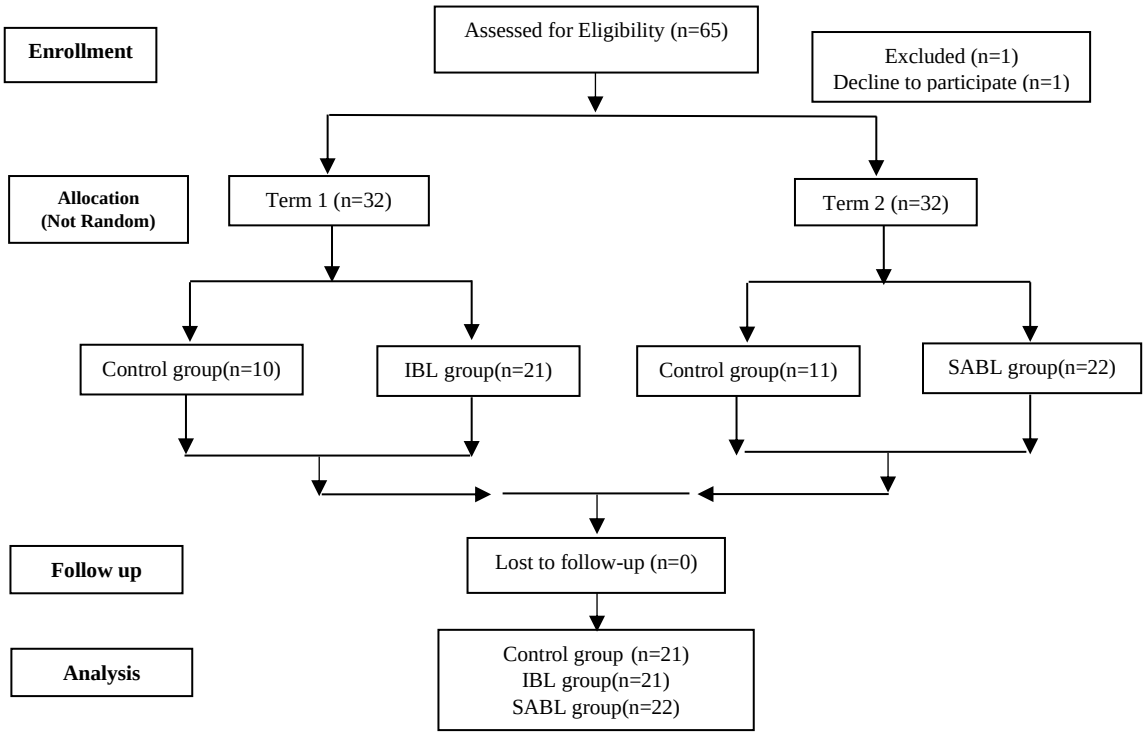

Figure 1. CONSORT flowdiagram

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Tools/Instruments

The data collection tools used in this study were the demographic characteristics information sheet (DCIS) and the CPSE questionnaire. The DCIS included demographic information, such as age, gender, marital status, clinical work experience, residential status, and interest in nursing. The CPSE questionnaire was developed by Cheraghi et al. (28) and consisted of 37 items assessing nursing students' self-efficacy in four main dimensions: patient assessment, nursing diagnosis and care planning, implementation, and evaluation. The items were rated on a five-point Likert scale, with responses ranging from not confident at all to completely confident, assigned a score of 1 to 5, respectively. The total score on the questionnaire ranged from 37 to 185, with higher scores indicating higher levels of CPSE. Cheraghi et al. confirmed the content and construct validity, as well as the reliability of the questionnaire, and reported that Cronbach's alpha values of the questionnaire and its dimensions were 0.70 and 0.90, respectively (28).

Data collection methods

The research aims and procedures were thoroughly explained to the participants, and they were informed that they could withdraw from the study at any stage. They were also informed that they would receive information about the study outcomes if they desired. Prior to data collection, the mentors read out a data letter from the research team that emphasized the voluntary and anonymous nature of participation. Data were collected face-to-face, with prior arrangements made, on the first and last days of the internship, and with the consent of the mentors. The data collection was conducted in a quiet educational setting in the NICU, where the sixth-semester nursing students were working under the supervision of the researcher.

The content of the Healthy Child Nursing and Pediatric Nursing Internship courses was developed by the outlines of the Supreme Council of Cultural Revolution in Iran and the objectives of the courses, using the main course resource, Wong's Nursing Care of Infants and Children, as well as other scientific textbooks, while consulting with nursing and medical experts. The content was coordinated between the two courses.

The SBAL group (n=21) and the IBL group (n=22) received six training sessions (60 minutes each session) along with conventional clinical education, and the control group (n=21) received conventional clinical education in the NICU during their internship. In the first two weeks of the internship, three days a week (Saturday, Sunday, and Monday), one session per day (60 minutes each session), a total of six training sessions were conducted for each intervention group. The educational content related to the intervention, which was confirmed by three pediatric nursing faculty members and two NICU head nurses, is presented in Table 1.

Table 1. Content of intervention learning groups in the Neonatal Intensive Care Unit

Week	days	Main purpose of teaching	Topics
First	1	Familiarity with general concepts related to neonatal care methods	Providing the relevant lesson logbook Psychological preparation, providing safety tips, infection control, restraint, and maintenance practices for treatment Nutrition methods, home care training
	2	Importance and review of high-risk neonates	Identification of high-risk neonates, nursing measures in high-risk infants, methods of examination, and examination of infants Serum therapy, medication, serum calculations, and discharge plan
	3	Nursing care of common problems of high-risk neonates based on the nursing process	Jaundice, respiratory problems (respiratory distress syndrome, transient neonatal tachypnea, meconium aspiration syndrome) Neonatal sepsis, Necrotizing Enterocolitis
Second	4	Nursing care for neonates with neuromuscular and musculoskeletal abnormalities based on the nursing process	Hydrocephalus, neonatal seizures, Congenital Dysplasia Hip, congenital clubfoot, cleft lip, and palate
	5	Nursing Care for Neonates with Abnormalities Based on the Nursing Process - Part One	Esophageal atresia and tracheoesophageal fistula, Diaphragmatic hernia, Spina Bifida
	6	Nursing Care for Neonates with Abnormalities Based on the Nursing Process - Part II	Anal and Rectal Abnormalities, Emphysema, Bladder Exstrophy, and hypospadias - sexual ambiguity

In the IBL approach proposed by Seif (2001) in Iran (29), the instructor first established educational goals. In the second stage, a puzzling situation was presented, and the students were asked to identify and raise questions related to the situation. They were encouraged to collect information needed to address their questions and to test their hypotheses objectively and orally. The instructor also motivated the students and valued their ideas. In the third stage, the student's activities and the obtained results were evaluated by the instructor, who provided feedback to them. Finally, in the fourth stage, the

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students reflected on their thinking processes with the help of the instructor.

In the SBAL, the instructor introduced a smartphone-based messaging application for the care of infants admitted to the NICU during the first two weeks of the Healthy Child Nursing and Pediatric Nursing Internship courses. In this group, the intervention provided care information based on the nursing process throughout the first two weeks of the internship in six online sessions of 60 minutes each (held on Saturday, Sunday, and Monday) through an educational channel for group discussion and commentary. Another channel was created only for providing educational content on WhatsApp.

During orientation meetings, the previous sessions were reviewed for the first 15 minutes of the internship. The content of each training session was then sent to the students in the group as a portable document format (PDF). file, and they were asked to refer to the educational channel to upload and read the materials. The educational content was collected from several reference books, including Wong's Nursing Care of Infants and Children, Marlowe's Textbook of Pediatric Nursing, and NANDA International Nursing Diagnoses: Definitions & Classification, which are commonly used in NICUs, and were approved by physicians and nursing educators.

During the internship, the students performed the nursing process for several patients, and each student was asked to thoroughly examine one patient and practice the nursing process. They were required to submit their reports during the second week of the internship. The groups were invited again to gather data one week after each intervention. In addition, two weeks after the second intervention ended, the educational content that was prepared for the intervention groups was shared with all control groups.

Data analysis

The collected data were first analyzed using the Shapiro-Wilk test to determine normality. The Chi-Square and Fisher Exact tests were used to assess the homogeneity of groups for qualitative variables. The paired t-test was used to compare means if the data were normal. The one-way analysis of variance (ANOVA) test was used to compare the means of three groups with a normal distribution. The Kruskal-Wallis test was utilized instead of ANOVA if the data were not normally distributed. If the ANOVA or Kruskal-Wallis test was significant, the Bonferroni test was used to compare the two groups. The data were analyzed in SPSS software (version 24.0), and P-values less than 0.05 were considered statistically significant.

Results

There was no significant difference between the three study groups in terms of gender distribution (P=0.319), marital status (P=0.592), place of residence(P=0.318), work experience (P=0.971), mean age (P=0.115), grade point average (P=0.255), healthy child nursing course score (P=0.582), and pediatric nursing internship course score (P=0.577) (Table 2). The mean post-test score of the CPSE evaluation domain in the control group receiving conventional clinical education was not significantly different from the pre-test value (P=0.106). However, in other domains, the score increase in this group was significant (P<0.05). On the contrary, the post-test score was significantly higher than the pre-test value in the intervention groups taught by SBAL and IBL (P<0.05).

Table 2. Comparison of Iranian undergraduate nursing students' demographics chartists among three groups

Characteristics		Groups: Conventional clinical education	Groups: Inquiry-based learning	Groups: Smartphone-based application learning	Statistic	*Sig.*
		Mean(SD[b])	***Mean(SD)***	***Mean(SD)***		
Age		22.05(1.56)	21.52(0.81)	23.05(3.71)	F= 2.24	0.115*
GPA[a]		15.85(1.21)	16.19(1.12)	15.61(1.01)	F= 1.40	0.255*
Healthy Child Nursing course score		17.03(1.82)	16.49(2.19)	17.02(1.69)	F= 0.557	0.582*
Pediatric Nursing Internship course score		15.46(1.79)	15.27(2.01)	14.87(1.90)	F= 0.55	0.577*
		n(%)	**n(%)**	**n(%)**		
Gender	Female	12(57.14)	8(38.10)	13(59.09)	$\chi^2 = 2.29$	0.319**
	Male	9(42.86)	13(61.90)	9(40.91)		
Marital status	Single	19(90.48)	20(95.24)	21(95.45)	$\chi^2 = 0.57$	0.592***
	Married	2(9.52)	1(4.76)	1(4.55)		
Work experience	Yes	3(14.29)	1(4.76)	5(22.73)	$\chi^2 = 0.00$	0.971**
	No	18(85.71)	20(95.24)	17(77.27)		
Resident status	native	13(61.90)	9(42.86)	14(63.64)	$\chi^2 = 2.29$	0.318**
	ow	8(38.10)	12(57.14)	8(36.36)		

Note:* One Way ANOVA; ** Chi-square test; *** Fisher's exact test
Abbreviations: SD, Standard Deviation; GPA, Grade Point Average**;** Sig**,** significancy; χ^2 ,Chi-square

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The mean CPSE scores increased significantly after SBAL, IBL, and conventional clinical education groups, averaging 45.00, 36.18, and 10.71, respectively (P<0.001) (Table 3). The amount of increase in the intervention groups receiving SBAL (P<0.001) and IBL (P<0.001) was greater than that in the control group. Nevertheless, the SBAL and IBL groups did not differ significantly in the amount of increase (P=0.191). In all domains of CPSE, the amount of increase in the post-test scores compared to pre-test values was significantly different in the three study groups (P<0.001 in all cases) (Table 3). The amount of increase in all domains in the intervention group taught by SBAL (P<0.001) and IBL (P<0.01) was higher than that in the control group receiving conventional clinical education. However, the difference in the amount of increase in the two intervention groups was not significant (P>0.05).

Table 3. Comparison of the Clinical Performance Self-Efficacy (CPSE) mean scores and related domains among the three groups

CPSE Domains	Groups	Before intervention	Statistic and *Sig.*	After intervention	Statistic and *Sig.*	Before and after changes	Statistic and *Sig.*
		Mean(SD)		*Mean(SD)*		*Mean(SD)*	
Neonate assessment	A	34.71(5.20)	F=1.59 P=0.212	37.48(6.09)	F=10.220 P<0.001	2.76(5.51)	F=10.96 P<0.001
	B	34.76(6.95)		48.19(8.48)		13.43(9.48)	
	C	31.59(7.68)		41.50(8.44)		9.91(7.07)	
Diagnosis and planning	A	24.67(4.52)	F=2.32 P=0.107	28.71(4.68)	F11.109 P<0.001	4.05(4.86)	χ^2 =22.41 P<0.001*
	B	24.67(6.29)		36.14(5.48)		11.48(6.80)	
	C	21.45(6.01)		32.95(5.18)		11.50(5.58)	
Implementing a care program	A	30.00(5.35)	F=0.21 P=0.811	32.81(6.45)	F=8.71 P<0.001	2.81(3.83)	F=15.45 P<0.001
	B	28.90(7.03)		40.90(6.89)		12.00(5.61)	
	C	29.95(6.13)		38.41(5.98)		8.45(6.40)	
Evaluation	A	17.24(3.94)	F=0.97 P=0.383	18.33(3.17)	F=10.63 P<0.001	1.10(2.97)	F=16.56 P<0.001
	B	15.90(3.24)		24.00(4.89)		8.10(4.23)	
	C	15.59(4.88)		21.91(3.85)		6.32(4.84)	
Total CPSE	A	106.62(16.79)	P=0.38 F=0.979	117.33(18.40)	F=12.30 P<0.001	10.71(11.21)	χ^2 =37.09 P<0.001*
	B	104.24(19.77)		149.24(23.71)		45.00(18.47)	
	C	98.59(21.20)		134.77(20.19)		36.18(15.39)	

Note: A, The conventional clinical education group, B: The inquiry-based learning group, C: The smartphone-based application learning group; *Kruskal Wallis; Otherwise ANOVA test

Abbreviations: SD,Standard Deviation; Sig**,** significancy; χ^2 ,Chi-square

Discussion

The results of this study pointed out that the increase in CPSE among nursing students in the intervention groups taught SBAL and IBL was higher than that in the control group receiving conventional clinical education. In addition, in all four domains of CPSE based on the nursing process (patient examination, nursing diagnosis, planning, and implementation of care program and evaluation), the score increase after the intervention in the SBAL and IBL groups was higher than that in the control group with conventional clinical education. Nonetheless, this difference in the two interventions was not statistically significant.

Zhang et al. (2019) found that undergraduate nursing students who received IBL had significantly higher scores in professional relationships and ethical decision-making compared to those who received lecture-based instruction (30). In a similar vein, Chau et al. (2021) combined inquiry- and technology-based learning programs among 192 fourth-year undergraduate nursing students during a one-month neonatal injury management training program and revealed that the students' levels of knowledge had significantly increased compared to before the program (31). Theobald and Ramsbotham (2019) also focused on the effect of IBL on students' clinical reasoning (22).

A wide array of studies have pointed to the significant effects of smartphone-based education. These include increasing self-efficacy knowledge and positive learning experience in chronic disease care (32), enhancing clinical reasoning and self-directed learning among undergraduate nursing students in South Korea (33), improving clinical practice in preventing medication errors in pediatrics among undergraduate nursing students in Iran (20), enhancing blood pressure measurement skills among nursing students in Turkey (34), as well as creating satisfaction and positive attitudes among graduate nursing students in Greece (35). In addition, some studies have demonstrated marked improvements in self-efficacy among nursing students through smartphone-based education (36).

In the study conducted by McMullan et al. (2011), no significant difference was detected in terms of improved drug calculation skills and self-efficacy of nursing

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students in the intervention and control groups after using interactive electronic drug calculation software. Nonetheless, students' satisfaction with the intervention as an effective method for learning, the availability of practice and feedback, user-friendliness, and enjoyment of learning were significantly boosted (37). In a similar vein, a review study by Zainudin et al. (2019) revealed that smartphone-based interventions using video and audio content, communication, and virtual learning improved the knowledge, skill performance, satisfaction, and self-efficacy of nursing students (38). It is worth noting that the results of related studies varied due to the use of various methods and materials in education systems. However, it is noteworthy that nursing students often face many barriers when putting theoretical knowledge into practice.

Nursing students often view the use of mobile devices, such as smartphones, as beneficial due to the creation of a self-learning environment with no limitations on time and place, easy access to learning materials, and the ability to engage in self-directed study (36). They can also use exploratory methods through discussion and conversation. Learning environments that prioritize practice for critical thinking and self-directed learning (22) can lead to a repetitive learning process with enhanced memory. In our study, although the IBL method led to more marked changes in the clinical self-efficacy score than the SBAL method, this difference was not significant. One possible reason for this could be the small sample size in the two groups.

Among the notable limitations of the present study, we can refer to the use of a self-report questionnaire to assess the impact of interventions. To evaluate the effect of interventions in future research, it is suggested to employ observational methods due to limited research on CPSE of the nursing process among students. Furthermore, it is recommended to compare the nursing process with various methods in different theoretical and practical courses in future studies. Another limitation of the study was the small sample size in the SBAL and IBL groups. Despite recruiting all eligible students enrolled in the School of Nursing and Midwifery affiliated with Urmia University of Medical Sciences, Iran, it is recommended to conduct a multi-center project with a larger sample size to increase statistical power. The third potential limitation is that, although the training of the IBL and SBAL groups was not simultaneous, there may have been a possibility of information leakage between the groups.

Conclusion

In conclusion, the findings of this study suggested that both SBAL and IBL can enhance the CPSE of nursing students undergoing conventional clinical training. Therefore, it is recommended to utilize these methods in clinical education based on the nursing process to enhance CPSE in nursing students. Nevertheless, there was no significant difference between the two methods in improving the self-efficacy of clinical performance. Future studies with larger sample sizes are recommended to compare the effectiveness of these methods.

Ethical considerations

The Ethics Committee of Semnan University of Medical Sciences approved the study (IR.SEMUMS.REC.1399.40). All participants were informed about the objectives and voluntary nature of the study, and written informed consent was obtained from them before the commencement of the study. Nursing students completed questionnaires anonymously and were informed that they would be informed about the results of the study if they wished.

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Disclosure

The authors have no conflict of interest.

Author contributions

SP and SY: Study conception/design, data collection, drafting of the manuscript, and critical revisions for important intellectual content.

RG: Study conception/design, data analysis, drafting of the manuscript, and critical revisions for important intellectual content.

Data availability statement

The datasets are available from the corresponding author.

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