

The Effectiveness of Simulation-based Formative Assessment in the Teaching of Perioperative Nursing Skills

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Abstract:

Background: The effectiveness of the simulation-based teaching approach and formative assessment in medical education has been justified, however, so far, no research data have shown the effect of formative assessment in the teaching of perioperative surgical nursing skills in simulated scenarios. **Method:** 78 third-year nursing students were selected as the research subjects and randomly divided into the experimental group and the control group for a semester of research. Traditional teaching methods were adopted in the control group, while in the experimental group, Standardized Patients (SPs) were utilized to create simulated scenarios, and the modified Mini-CEX was used for formative assessments, giving dynamic evaluation and real-time feedback. To understand the effectiveness of this teaching method, a summative evaluation and a survey questionnaire were conducted at the end of the semester. **RESULTS:** Nursing students in the experimental group scored significantly higher in examinations of procedural skills and all aspects of Mini-CEX than those in the control group did ($P < 0.05$). Nursing students generally approved the simulation-based Mini-CEX assessment model. **Conclusion:** The combination of simulation and formative assessment can effectively improve nursing students' procedural skills in surgical care and their comprehensive clinical competencies. Moreover, it is conducive to improving teaching quality and benefits mutual promotion of teaching and learning.

Keywords:

Mini-CEX, Standardized Patient (SP), Simulation, Formative Assessment, Surgical Nursing

1. Introduction

Clinical nursing skills are the core component of nursing practice, and perioperative surgical nursing skills are a vital part of clinical nursing skills. Research has shown that the gap between theoretical study and clinical practice can cause anxiety,

confusion, and other negative emotions, resulting in adverse effects on learning and nursing students' clinical performance. Therefore, it is a challenge for nursing educators to create appropriate educational conditions tailored to the characteristics of students to improve their clinical nursing skills. Studies found that creating a safe practice environment and close monitoring are conducive to improving nursing students' clinical competencies [1]. Simulation-based education is considered to be an effective educational method for nursing students to cultivate the competencies required for their careers [2]. Situational simulation in teaching can provide an immersive environment, allowing for teaching through guided experience in a safe environment and multi-sensory learning, thus reducing anxiety and improving students' clinical skills [3]. High-fidelity simulation scenarios created by Standardized Patients (SPs) can be used to cultivate comprehensive clinical competencies, including communication and decision-making skills, adaptability, and critical thinking. The simulated environment allows for trial-and-error opportunities for students to learn various perioperative nursing skills, without the risk of harming patients even if they make mistakes, which is not realistic in real clinical settings [4].

However, situational simulation must be built on sufficient teaching practice to achieve the desired effect, which requires effective feedback, repeated practice, multiple teaching strategies, a controllable environment, various clinical scenarios, and individualized teaching [5,6,7]. This requires nursing educators to continuously evaluate the learning effect during teaching, in addition to providing students with a practical environment to gain clinical experience. By evaluating the merits and shortcomings in learning and taking measures accordingly, teaching effects can be improved [8]. Therefore, assessment should not be regarded only as a means to test students' performance or passing of the course [9], but more importantly, as a way to motivate students in the learning process. Formative and summative assessments are widely used in simulation teaching. Formative assessment refers to the immediate, dynamic, and multiple evaluations of students' understanding of knowledge, learning progress, and learning demands. It particularly values timely feedback and emphasizes "assessing for learning" [10]. Studies have shown that formative peer assessment contributes to the development of professional practical skills. When used in medical education, it promotes teaching and learning by providing effective feedback.

Among the many types of formative assessment tools, Mini-clinical Evaluation Exercise (Mini-CEX) is an efficient and one of the most commonly used tools in medical education. It is widely used in checking knowledge mastery, tracking learning trajectory, planning professional practice skills, etc., which can provide teaching feedback well and guide students to carry out targeted learning [8,11,12,13]. Traditional Mini-CEX is often used to assess the clinical knowledge and skills of physicians, but it is not very applicable to nurses. Jin Yanyan modified Mini-CEX based on the Chinese characteristics of nursing education and achieved good reliability and validity [14]. And the improved version is being applied to the research of registered nurses and trainee nurses in China.

The role of situational teaching and Mini-CEX-based formative assessment in medical education has been recognized, but so far, there is no evidence that Mini-CEX-based formative assessment in simulated contexts can improve surgical perioperative nursing skills.

This study, using the improved version of Mini-CEX, explored the effect of formative assessment on the teaching of perioperative nursing skills in SP simulated scenarios in nursing courses.

2. Materials and Methods

This study was conducted at a medical school in China offering nursing education to undergraduate students and was approved by the school's Review Committee. In China, the Bachelor of Science in Nursing is a four-year program (two semesters each year), in which students complete three years of theoretical and practical study on campus, and then enter a hospital for a 10-month clinical internship before obtaining the bachelor's degree.

The Perioperative Nursing Practice Course in surgical nursing was offered in the fifth semester and this study lasted this whole semester. The theoretical part of the course was taught by the same teacher, and the practical part was carried out jointly by four instructors of the teaching and research group.

2.1. Research Subjects

Through cluster sampling, 78 third-year nursing students were selected as the research subjects and randomly divided into the experimental group and the control group. The experimental group consisted of 38 people, including 33 female students and 5 male ones, who were 20-25 years old with an average age of (21.50 ± 1.39) . In the control group, there were 40 students, including 32 females and 8 males between the ages of 19-24, with an average age of (21.95 ± 1.04) . There were no significant differences between the two groups in terms of age, gender, and previous course scores ($P > 0.05$).

To comply with ethical principles, students in the experimental could choose to participate in the study out of their own will, and if they do not want to be included in the experimental group for any reason, they can be transferred to the control group, which did not affect their course grades.

2.2. Methods

The teaching content of perioperative nursing skills consisted of six items: skin preparation in the operation area, putting on and taking off the aseptic operating gown and gloves, preparing surgical instruments, disinfecting cloth, replacing wound dressings, and drainage tube care. Among these, skin preparation in the operation area, replacing wound dressings, and drainage tube care require the cooperation of patients while the rest three items do not.

2.2.1 Control Group

The teaching of the six items was conducted in a traditional way in which the teachers first made demonstrations relating to the teaching cases in the experimental class, and the students observed and then practiced in groups. Both demonstration and practice were performed on manikins. No assessments were taken during the class apart from the ones in the middle and end of the course.

2.2.2. Experimental Group

For the three items involving the handling of objects, teaching was conducted according to the traditional way, while for the three items involving patients, the

Mini-CEX-based teaching strategy was adopted with the cooperation of SPs and implemented as follows:

2.2.2.1. Preparation

Before class, nursing students were trained on the modified nursing version of Mini-CEX to understand its content and usage. The evaluation scale covers seven aspects including medical interviewing, physical examination, nursing plan, procedural skills, health education, organization/efficiency, and humanistic care, with a total of 40 reference points.

Based on the teaching content, common surgery cases were selected and discussed by the teaching and research group as well as clinical experts and then compiled as standard teaching cases to create simulated scenarios.

Twenty SPs were selected from the SP pool as volunteers, trained in a centralized manner, and introduced in the teaching and skills assessment after they passed an examination.

2.2.2.2. Implementation

In the experimental class, the teacher demonstrated the procedures of surgical nursing based on the key reference points of Mini-CEX in the contexts of SP simulation and explained the procedures in detail. In the whole process, in addition to cooperating with students, SPs would bring up some special situations and problems to guide the nursing students to think and take corresponding measures, rather than simply conducting the procedures mechanically.

Nursing students were divided into groups of 3-4 people to practice referring to the assessment points of Mini-CEX in SP simulated situations. They were trained not only to learn various nursing procedures but also to handle the discomfort of SPs timely and appropriately and to communicate with them effectively. Each practice item covered two teaching hours in the classroom and two in the open-ended laboratory under the guidance of instructors. In each experimental class, demonstration and explanation took 10-20 minutes, followed by 2-3 exercises of the targeted practice item for each student with the cooperation of SPs in simulated situations. In the process, depending on the students' level of mastery, different surgery cases can be presented by SPs to consolidate students' procedural skills. More importantly, by simulating different scenarios, students were asked to communicate with and care for different "patients", adopt tailored nursing measures and attend to different needs of "patients". In this way, students needed to think before taking measures, consider SPs' feelings, and communicate with them effectively, rather than conducting nursing practices mechanically. Thus, their critical thinking skills and humanistic care ability were cultivated effectively.

After class, the laboratory was opened for nursing students to practice on their own. Through repeated practices, short-term memory of perioperative nursing skills would turn into long-term memory, and independent thinking, good judgment, and humanistic care for patients required during nursing operations were habituated.

After the practice of each item, one nursing student was randomly selected from each group as the examinee, and different students were selected from the three practice items involving patient cooperation to ensure that each nursing student was assessed at least once in the experimental class. Other group members and teachers

formed the assessment group to assess the examinee using a scale of 1 to 9, with grades 1 to 3 as not meeting the standard, grades 4 to 6 as meeting the standard, and grades 7 to 9 as excellent. After the assessment, on-site feedback was conducted. The student assessors needed to point out the strengths and weaknesses of the examinees in the whole process of practice. Also, the examinees needed to reflect upon their weaknesses for improvement in their future learning and practice. In each assessment, the observation took 10-15 minutes, and feedback 5-10 minutes.

2.3. Observation Indicators

a. Scores of procedural skills assessment: students of the experimental and the control group were assessed on a randomly chosen perioperative nursing practice item using traditional scoring standards halfway and at the end of the course.

b. Mini-CEX summative assessment: after the completion of the course, a summative assessment was taken to assess students' overall nursing competencies including medical interviewing, nursing plan, procedural skills, health education, and humanistic care. One of the three nursing items involving patients was chosen for the assessment in the context of SP simulation.

c. valuation of the effectiveness of Mini-CEX in the simulated scenarios: A questionnaire was designed by referring to relevant research literature to investigate the two groups of nursing students. The questionnaire consisted of nine items, each of which includes three options: "Agree", "Neither agree nor disagree", and "Disagree".

2.4. Statistical Analysis

The statistical software SPSS 19.0 was chosen to show the measurement data ($\bar{X} \pm S$) and the count data (%) respectively, and the t-test was used for statistical analysis, with $P < 0.05$ indicating that the differences were significant.

3. Results

3.1. Comparison of the Nursing Students' Scores in the Two Examinations

In the mid-semester examination, the average score of the control group was (80.39 ± 5.42), and that of the experimental group was (80.25 ± 3.89), indicating no big differences in procedural skills between the two groups ($P > 0.05$). However, at the end of the course, the experimental group (average score 87.34 ± 2.08) scored significantly higher ($P < 0.05$) than the control group (average score 81.58 ± 2.11). At the same time, there were no significant differences in the scores of the two examinations in the middle and end of the semester in the control group ($P > 0.05$), while in the experimental group, students scored significantly higher in the final assessment than in the mid-semester one ($P < 0.05$) (Table 1).

Table 1. Comparison of the nursing students' scores in the two examinations.

Item	Mid-semester exam	Final exam	t-value	P
Experimental group (n=38)	80.39±5.42	87.34±2.08	-7.377	0.000
Control group (n=40)	80.25±3.89	81.58±2.11	-1.898	0.061
t-value	0.135	12.138		
P	0.892	0.000		

3.2. Comparison of the Two Groups' Scores in Mini-CEX-based Summative Assessment

At the end of the course, a summative assessment of the two groups was conducted using Mini-CEX in SP simulated scenarios. The scores of the control group in the seven aspects are: medical interviewing (5.24±1.03), physical examination (5.26±0.76), nursing plan (3.92±1.00), procedural skills (5.37±0.94), health education (5.03±0.82), organization/efficiency (4.53±0.73), and humanistic care (4.74±0.92); the scores of the experimental group are: medical interviewing (6.45±1.15), physical examination (5.97±0.77), nursing plan (5.09±0.98), procedural skills (6.09±0.81), health education (5.70±0.64), organization/efficiency (5.03±0.77), and humanistic care (6.00±0.87). It can be seen that the experimental group scored higher than the control group in all seven aspects of the assessment ($p < 0.05$) (Table 2).

Table 2. Comparison of the two groups' scores in Mini-CEX-based summative assessment.

Group	Number of students	Medical interviewing	Physical examination	Nursing plan	Procedural skills	Health education	Organization/efficiency	Humanistic care
Experimental group	38	6.45±1.15	5.97±0.77	5.09±0.98	6.09±0.81	5.70±0.64	5.03±0.77	6.00±0.87
Control group	40	5.24±1.03	5.26±0.76	3.92±1.00	5.37±0.94	5.03±0.82	4.53±0.73	4.74±0.92
T-value		4.722	3.883	4.971	3.446	3.801	2.838	5.926
P-value		0.000	0.000	0.000	0.001	0.000	0.006	0.000

3.3. 71 Nursing Students' Evaluation of the Effectiveness of the Mini-CEX Assessment Model in Simulation Scenarios

The survey showed that the 78 nursing students held a positive attitude toward the Mini-CEX assessment model in simulation scenarios and were generally satisfied with this assessment approach. According to the survey, 89.7% of the nursing students agreed that the Mini-CEX assessment was scientific and fair, the rest 10.3% neither agree nor disagree with this statement. 79.5% of the nursing students agreed that this assessment method was simple and accessible, while 7.7% disagreed and 12.8% neither agree nor disagree. 83.3% of the research subject thought this evaluation method could test their flexibility and on-site problem-solving ability, while 6.4% did not think so and 8% of them held a neutral attitude. 79.5% of the nursing students thought that their transferability of knowledge and skills could be reflected in the evaluation, while 6.4% of them held a negative opinion and 14.1% held a neutral attitude. 92.3% of the nursing students believed that this assessment model could promote teaching and learning, while the rest 7.7% held a neutral attitude. In terms of boosting self-confidence, 76.9% of the nursing students held a positive opinion, while 7.7% disagreed and 15.4% were neutral on this point. More than 80% of the nursing students held positive opinions in terms of improving humanistic care ability (87.2%), nurse-patient communication (84.6%), and comprehensive clinical competencies (80.8%). (Table 3).

Table 3. Evaluation of the Mini-CEX-based assessment model in simulation (n=78) unit: person (%).

Item	Agree	Neither agree nor disagree	Disagree
Assessment is scientific and fair	70 (89.7)	8 (10.3)	0 (0.0)
Assessment is simple and accessible	62 (79.5)	10 (12.8)	6 (7.7)
Can reflect flexibility and on-site problem-solving ability	65 (83.3)	8 (10.3)	5 (6.4)
Can reflect transferability of knowledge and skills	62 (79.5)	11 (14.1)	5 (6.4)
Can promote teaching and learning	72 (92.3)	6 (7.7)	0 (0.0)
Can boost self-confidence	60 (76.9)	12 (15.4)	6 (7.7)
Value humanistic care	68 (87.2)	8 (10.3)	2 (2.5)
Conducive to nurse-patient communication	66 (84.6)	7 (9.0)	5 (6.4)
Improve comprehensive clinical competencies	63 (80.8)	9 (11.5)	6 (7.7)

4. Discussion

The results of this study showed that the difference between the average score of students' perioperative nursing skills in the experimental group at the middle of the semester (80.39 ± 5.42) and that at the end of the semester (87.34 ± 2.08) was statistically significant ($P < 0.05$), while the difference between the average score of the control group at the middle of the semester (80.25 ± 3.89) and that at the end of the semester (81.58 ± 2.11) showed no statistical significance ($P > 0.05$). It indicated that SP simulation and the application of Mini-CEX in the formative assessment played a positive role in improving students' perioperative nursing skills. Ross et al also mentioned in their research that it is an effective teaching strategy to use SP to impart knowledge to students [15]. Studies have shown that simulation-based learning is a flexible and successful approach with a positive effect on improving clinical skills and the learning quality of medical students [5,16,17,18]. Maroufi et al. believed that it is necessary to strengthen the supervision of formative assessment and promote the use of this assessment method and its continuous monitoring in colleges [19,20]. The research of Lörwald et al. also revealed that under the influence of feedback and a conducive learning environment, students can get higher scores [21]. Hosseini et al. showed that Mini-CEX is more effective in improving nursing students' skills than traditional methods [11].

The results of this study are in line with the aforementioned research. The scores of the experimental group (80.39 ± 5.42) and the control group (80.25 ± 3.89) in the mid-semester assessment showed no significant difference ($P > 0.05$), but for the end-of-semester assessment, the experimental group (87.34 ± 2.08) scored significantly higher than the control group (81.58 ± 2.11) ($P < 0.05$). Na et al. showed in their research the importance of formative assessment through summative evaluation of students' performance. Formative assessment should be used to promote learning rather than just providing grades [10]. Vafaei et al. noted in 2017 that providing feedback to students significantly improves their performance on subsequent assessments, thus enhancing their skills [22]. Mini-CEX, as a tool of both assessment and feedback, provides a formative assessment of the entire learning process through diversified teacher evaluation and students' peer assessment. By alternating the roles of the observer and the observant, formative peer assessment brings into full play the

nursing students' initiative, changing them from passive recipients of knowledge into proactive participants of the learning process as they can reflect on their own mastery of knowledge and skills when they observe and assess their peers. After the assessment, students were then trained according to the reference points of the seven aspects of Mini-CEX, so that they can familiarize themselves with the nursing processes of "assessment-diagnosis-planning-implementation-evaluation". The introduction of SPs creates repeatable, highly-fidelity simulation scenarios in which students are trained not only in procedural skills but also in their competencies in medical interviewing, physical examination, health education, etc. Moreover, the cooperation of SPs makes the whole nursing process more clinical and practical, and students can be trained repeatedly for optimal outcomes. This is in line with Buist's view that simulation provides repeatability, which is vital to improving learning outcomes[23]. KUMAR et al. also pointed out that students have a better understanding of their strengths and weaknesses after oral feedback, which can enhance students' learning [24].

The ultimate goal of nursing education is to train competent nurses to a high standard of patient care. Therefore, it is paramount to improve nursing students' practical skills and clinical competencies [8]. As the results of this study showed, the experimental group scored higher than the control group ($P < 0.05$) in all the seven aspects of medical interviewing, physical examination, nursing plan, procedural skills, health education, organization/efficiency, and humanistic care in the Mini-CEX based summative assessment under SP simulation at the end of the semester. It is seen that through a semester's simulation training and with the help of dynamic feedback from the formative assessment, the students were guided to regulate their learning process, develop autonomy and interest in learning, and enhance their professional knowledge and procedural skills. At the same time, their overall nursing competencies including professional ethics, clinical thinking, teamwork, etc. have also been improved. In the findings of Lim et al., students favored the use of formative assessment and the corrective feedback it provided in medical education [9]. The results of another study by Lwald et al. revealed the positive role of Mini-CEX in improving communication skills, knowledge transferability, and teamwork, all of which are core competencies in clinical care [25]. As most surgical patients need to undergo surgical operations, they need more psychological support before and after surgeries. Simulation training can improve nursing students' empathy and thus improve the quality of care in the operation rooms, which is in line with the results of Larti's study [26]. Choudhari applied Mini-CEX to formative assessment among a cohort of graduate students, and it turns out that it is a feasible, acceptable, and effective approach for improving the overall learning ability of the students [27]. The results of Baek & Park's study showed that the situational approach is effective in developing nursing students' team effectiveness, systematic thinking, and initiative in problem-solving, which helped nursing students adapt to the clinical setting as early as possible [28]. Qureshi & Zehra's study highlighted the effectiveness of SPs' feedback in improving the communication skills of undergraduate medical students [29]. Results from an exploratory study by Walker & Roberts suggested that students produced better outcomes in their practice of core nursing skills on SPs than on their peers. Besides, they performed better in counseling and communication skills, clinical judgment, consideration of patients, professionalism, organization efficiency, and clinical competencies. Students also reported that they were more professional, better prepared, and more focused before the class [30]. The research results of Jiménez et al. showed that training in a high-fidelity simulation environment had a positive impact

on students' learning motivation as well as critical thinking [31]. Munn and Uymaz et al. both showed that simulation experience in nursing courses can consolidate students' mastery of knowledge, improve their performance, and prepare them for the clinical environment. At the same time, simulation provides students with the opportunity to gain experience in areas that are rare in clinical settings, thus boosting the learning and self-confidence of undergraduate nursing students [32,33]. The study by Cortés-Rodríguez et al. also suggested that SP simulation significantly enhanced students' knowledge, skills, self-efficacy, and competency in professional communication in geriatric nursing [34]. Alshutwi et al. also approved simulation in their findings as a valuable teaching strategy that can improve nursing students' learning outcomes, in addition to developing their skills in assessment, critical thinking, observation, and communication [35]. Arrogante et al. showed in their research that students were more satisfied with clinical simulations when assessed with formative assessment. Nursing students who participated in the study recognized the advantage of clinical simulation as a useful teaching method, which helped to bridge the gap between theories taught in the classroom and clinical practice, and prepared them for their clinical practice and future careers [2]. Green et al. found that simulation-based learning can effectively improve students' sensory and perceptual abilities in nursing and learning satisfaction. The effect was immediate in the simulation as well as one month later [36]. Tseng et al. explored the effectiveness of the application of clinical simulation integrating information technologies in surgical and internal nursing as well as in critical care courses, and the results showed that this new teaching method can promote learning effectively in a short time and improve clinical nursing skills [37].

The main focus of the summative evaluation in the traditional teaching method is only on students' final scores in their assessment of skills, and their comprehensive competencies are neglected. The Mini-CEX-based assessment in simulated contexts, in contrast, examines students' problem-solving ability and assesses them comprehensively from seven aspects. As the results of this study showed, the students generally recognized this evaluation method as an acceptable way to reflect the effectiveness of learning in one semester. Siska's study also showed that Mini-CEX is an effective method to assess nursing students' clinical skills [12].

5. Limitations

Firstly, the data in this study were collected from a small sample of a university, so further studies may be needed to verify the validity of the findings. Secondly, although both simulations and formative evaluations are recognized for their effectiveness in teaching, they require significant time and effort in both instructional design and implementation, which put forward greater demand for teachers.

6. Conclusions

The conclusion that SP simulation narrows the gap between theory and practice in the teaching of perioperative nursing skills, providing a safe learning environment close to the clinical settings for nursing students. The Mini-CEX-based formative assessment serves to give dynamic evaluation and real-time feedback, so that teaching and learning can be adjusted flexibly in a mutually promoting way. The combination of simulation and formative assessment improves not only students' learning outcomes and comprehensive clinical competencies but also teachers' teaching quality.

However, further studies are needed to fully verify the validity of the results and to promote it in other nursing courses.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Author Contributions

Conceptualization: Pang Xiaoli, Zhai Huimin, Guo Zhiqiang, Guo Liyan, Deng Ying.; Methodology: Pang Xiaoli, Guo Zhiqiang, Guo Liyan.; Investigation: Guo Zhiqiang, Guo Liyan, Deng Ying.; Data Curation: Guo Liyan, Deng Ying.; Writing – original draft preparation: Pang Xiaoli.; Writing – review and editing: Pang Xiaoli, Zhai Huimin.; Project administration: Pang Xiaoli, Zhai Huimin.

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