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Research Paper

Effects of the mini-clinical evaluation exercise teaching mode based on nurse-faculty cooperation in Fundamentals of Nursing course: A quasi-experimental study

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ABSTRACT

Objectives: This study aimed to explore the effects of the mini-clinical evaluation exercise (mini-CEX) teaching model based on nurse-faculty collaboration in Fundamentals of Nursing course.
Methods: A quasi-experimental design was conducted. A total of 111 nursing students of two parallel classes were recruited from a nursing college in Guilin, China from February to December 2022, and allocated to the intervention group ($n = 56$) and control group ($n = 55$). The intervention group received a mini-CEX teaching model based on nurse-faculty collaboration, the teaching-learning process included scenario creation (10 min), inquiry-based learning (30 min), case report (30 min), scenario simulation exercise (40 min), and effectiveness evaluation (10 min). While the control group received conventional teaching method. All students were invited to complete the College Classroom Climate Assessment Scale (CCCA) and the Chinese version of the Competency Inventory for Nursing Students (CINS-CV) before and after the intervention. Course achievement of students was evaluated. After the intervention, the intervention group was asked an open-ended question to explore the difficulties or challenges they had encountered.
Results: After intervention, the CCCA score (208.36 ± 23.25 vs. 190.60 ± 28.83), CINS-CV score(106.95 ± 14.48 vs. 99.55 ± 14.60), the oretical exam score (83.01 ± 4.27 vs. 79.75 ± 5.45), and scenario simulation exam score (89.23 ± 3.17 vs. 81.42 ± 7.19) of intervention group were higher than those of the control group ($P < 0.01$). The open-ended questionnaire survey revealed that the difficulties or challenges faced by the intervention group were mainly related to case analysis, group cooperation, learning material acquisition, and teacher guidance.
Conclusion: Applying the mini-CEX teaching model based on nurse-faculty collaboration could cultivate nursing students' competency, build a positive classroom climate, and improve the course achievement of students.

What is known?

- Chinese government has prioritized medicine education coordination, making it a core component of China's medicine education reform and an effective way to train medical students.
- A mini-clinical evaluation exercise (mini-CEX) is a clinical scenario-based teaching and assessment tool that improves medical students' clinical knowledge, skills, and attitudes.
- Fundamentals of Nursing course is a basic, core, and compulsory course for nursing students.

What is new?

- The nurse-faculty collaborative mini-CEX teaching model improved nursing students' competency and course achievement and helped create a positive classroom climate.

1. Introduction

The mini-clinical evaluation exercise (mini-CEX) was developed and revised by Norcini et al. [1,2] as a teaching and assessment tool based on the six core competencies proposed by the American Council on Postgraduate Medical Education. Kogan et al. [3] established the strongest evidence of the validity of the mini-CEX through a systematic review of 55 tools for the direct observation

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and assessment of medical students' clinical skills, which can effectively cultivate the clinical knowledge, skills, attitudes, and other abilities of students [4,5]. Notably, Chen et al. [6] introduced the mini-CEX to China and revised it according to their research experience and cultural background. Additionally, Yi et al. [7] constructed the Nursing-mini-CEX scale through Delphi method based on the original mini-CEX research combined with clinical teaching characteristics of nursing undergraduates. Huang et al. [8] reported that the application of the mini-CEX improves quality of nursing teaching and learning, which is important for enhancing competency of nursing students. Recently, as the use of mini-CEX in nursing education has increased, many nursing educators have noted several associated issues and challenges. The mini-CEX has mainly been used to assess students during clinical practice. However, because students rarely experience teaching and training in clinical scenario simulations during their course of study, they need help adapting to this assessment method quickly. Moreover, some teachers needed to receive systematic training before applying the mini-CEX and overemphasized its assessment function; this attitude led them to neglect their teaching function and not supply sufficient teaching feedback. These issues led to the formalistic application of the mini-CEX.

Cooperative teaching (co-teaching) is the collaborative involvement of two or more faculty members from the same discipline in all elements of the course instructional process, including course design, course preparation, course instruction, and instructional evaluation. It has been used as a teaching strategy in educational settings in many subject areas, including clinical medicine, nursing, and social work [9–11]. As a cooperative education model, collaboration can realize complementary advantages and resource sharing, effectively promoting medical education's reform and innovative development and cultivating medical talents [12–14]. In the past decade, the exploration of collaborative teaching in nursing education can be categorized into four models: interprofessional collaborative teaching [15,16], nursing-doctor collaborative teaching [17,18], nurse-faculty collaborative teaching [9], and collaborative teaching by multiple faculty members [19,20]. A systematic review found that medical students had positive attitudes toward co-teaching, during which they better perceived the connections between medical theory and clinical practice. They also participated more in the classroom process, optimizing their learning experience and outcomes [21]. Research on collaborative teaching in Chinese nursing education has mainly focused on talent training models, evaluation systems, postgraduate education, and the construction of teaching resources.

Nursing is a comprehensive discipline with strong practicality and application; accordingly, it should be guided by nursing competency and combined with theory and practice while integrating clinical education into the entire process of nursing college education [22]. In this study, nurse-faculty cooperation was conducted through a dual-qualification course-teaching team consisting of clinical nurses and nursing faculty. The team collaboratively developed the teaching syllabus, prepared clinical nursing example cases, performed situational simulation teaching, and guided students in mutual and self-assessment to determine whether students had achieved the required nursing competencies and understood the course content. This approach is conducive to mini-CEX teaching. Unlike most nursing educators, we used the mini-CEX as an evaluation and feedback tool and utilized its evaluation content as a framework for teaching content. This study confirmed the efficacy of the mini-CEX teaching model based on nurse-faculty collaboration in supporting nursing students' competency, course achievement, and classroom climate.

2. Method

2.1. Study design and participants

This study was conducted in the second year of Baccalaureate nursing students from February to December 2022, at a nursing college in Guilin, Guangxi Zhuang Autonomous Region, China. A convenience sample of second-year undergraduate nursing students was recruited for this study. The sample inclusion criteria were as follows: i) no previous experience in the *Fundamentals of Nursing*; ii) underwent basic medical courses as a freshman; iii) had no prior experience in scenario-based simulation training; iv) provided voluntary informed consent to participate in the study. The sample size was calculated using the formula $n_1 = n_2 = 2^*[(\mu_\alpha+\mu_\beta)/(\delta/\sigma)]^2$ [23]. By setting $\alpha = 0.05$ and $\beta = 0.10$, $\mu_\alpha = 1.96$ and $\mu_\beta = 1.28$. According to the study by Wang et al. [24], the baseline mean score of the Chinese version of the Competency Inventory for Nursing Students (CINS-CV) was 209.33 ($SD = 8.91$), and it reached 217.98 ($SD = 6.06$) after implementing a scenario simulation teaching intervention. The recommended sample size was 80. After adjusting for a dropout rate of 20%, the minimum number of participants required was 96. The number of students in the two classes ($n = 111$) in this study met the sample size requirement.

This study employed a quasi-experimental design. As the students in our study were from two parallel classes at one university, randomly assigning students to control their interactions with each other was impossible. Therefore, after comparing two parallel classes with no statistically significant differences in general information, the socre of College Classroom Climate Assessment Scale (CCCA) and CINS-CV at the $P < 0.05$ level before the intervention, we assigned the two parallel classes to the intervention and control groups.

2.2. Interventions

Fundamentals of Nursing course is a bridge course for nursing students to transition from theory to practice, and its teaching purpose is to enable nursing students to master the basic theories, knowledge, and skills of nursing, which is a key link in cultivating the clinical working ability and comprehensive clinical quality of nursing students. Evidence from relevant studies demonstrates that the mini-CEX effectively develops students' clinical knowledge, skills, attitudes, and other competencies [4,5]. This study was based on the modified nursing mini-CEX of Yi et al. [7] for instructional design; the content of the nursing mini-CEX includes eight aspects: nursing consultation, nursing assessment, nursing diagnosis, nursing measures, health consultation, humanistic care, organizational effectiveness, and overall evaluation. Students must complete case reports on the nursing mini-CEX content and scenario simulation exercises through role-playing. We used the mini-CEX teaching method in the intervention group for vital sign measurement, oxygenation, sputum aspiration, enema, catheterization, various injections, nasal feeding, aseptic, and isolation techniques. The teaching methods for other *Fundamentals of Nursing* were the same in the intervention and control groups.

2.2.1. The intervention group

2.2.1.1. Formation of the teaching team. Ten teachers with teaching expertise in the Fundamentals of Nursing course were organized as this study's core research teaching teams. All of them held higher teacher and nurse practice qualification certificates, including five faculty members from the nursing college (i.e., two professors, two lecturers, and one assistant professor) and five clinical nursing specialists from affiliated hospitals (each from the departments of medicine, surgery, gynecology, pediatrics, and emergency

medicine). The teaching team conducted preliminary analyses and elaborated on learner and course characteristics, the teaching environment, teaching resources and content, and technical support through collective lesson preparation. Moreover, it jointly 1) studied the definition, development, content, and process of the mini-CEX and 2) completed the design of teaching plans and processes, case preparation, situational simulation teaching, and evaluations according to the requirements of the ting syllabus and clinical nursing work.

2.2.1.2. Development of the mini-CEX teaching nursing case base. Five case preparation teams were established, each with a full-time nursing college teacher and a clinical nursing expert. Each case was initially prepared by one teacher, reviewed by another teacher in the same group, cross-reviewed between groups, and finally submitted to the teaching team leader for review before finalization. All cases were derived from real clinical cases and integrated with the relevant knowledge points of Nursing Etiquette course and Nurse's Humanity Cultivation course, which were used to test students' humanistic quality and professional ethics. The case base covers common diseases and cases in the emergency department, internal medicine, surgery, gynecology, and pediatrics, such as drug anaphylactic shock, placenta previa, food poisoning, heart failure, pneumonia, diarrhea, cerebral infarction, rectal cancer, and the handling of medical negligence. The total class hours, teachers, course syllabi, open training room hours, and theory and operation textbooks for both groups were identical.

2.2.1.3. The implementation of curriculum teaching. The teacher divided the students in the intervention group into learning groups of six or seven students each, established a group through a social media platform for teacher–student communication, and posted clinical nursing cases, learning tasks, and operation videos to the group a week before class for students to prepare through team-based learning. Each lecture was jointly taught by the case-preparation team, with the case-writing teacher as the main teacher and another teacher on the case-preparation team as the assistant. Under the joint guidance of nursing college faculty and clinical nursing experts, the learning groups completed the case report, scenario simulation, and role-play required for nursing mini-CEX content [7] through teamwork in learning groups based on clinical nursing cases. Then they used the nursing mini-CEX for mutual evaluation and self-evaluation. Finally, the two teachers evaluated and provided feedback on the performance of the learning groups in class and provided suggestions for improvement. Table 1 presents the in-class teaching processes. After class, the teacher posted test questions for the students to review through the social media group and opened a training room to strengthen their operational skills.

2.2.1.4. Organization of the learning experience exchange workshop. Learning experience exchange workshops were arranged for teachers and students of the intervention group using audio and video conferencing software "Tencent Conferences." The workshops were held in the third and tenth weeks of each semester and lasted for approximately 40 min each. In each workshop, the teacher summarized the students' shortcomings in the class and provided suggestions for improvement. Subsequently, two or three learning groups that performed well in the report and role-play were selected to share their assignments and learning experiences, followed by teachers' comments and students' questioning and answering.

2.2.2. The control group

The control group adopted the conventional teaching mode in which each lecture was delivered independently by a nursing faculty member or a clinical nurse specialist. The teacher assigned learning tasks and materials to the students so that they could study before class, posted test questions in the social media group, and opened the training room after class. The theoretical teaching approach was classroom-based, with teachers giving classroom lectures, following chapters, emphasizing key points, difficult content, and case studies. The teacher taught practical training classes, coherently explained and demonstrated practical training operations, and highlighted the key steps. Student group exercises followed this. Finally, the teacher summarized the students' practical training process.

2.3. Ethical considerations

This study was approved by the Ethics Committee of Guilin Medical University (No.GLMC20210503). Each student who participated in this study provided informed consent and reserved the right to withdraw from the study at any time. To protect participants' confidentiality, information about their identities was not collected, and all responses were anonymous.

2.4. Instruments

2.4.1. General information questionnaire

General information included sex, habitual residence, basic medical course grades, and professional attitudes. The professional attitude was investigated on how much the students liked nursing work, using a 3-point Likert scale, with "1 = dislike," "2 = general," and "3 = like." The grade of basic medical courses was used to evaluate students' learning in their first year of basic medical courses, with a score of less than 70 being "qualified and below," a score of 70–89 being "moderate," and 90 or above being "excellent."

2.4.2. College Classroom Climate Assessment Scale

The CCCA is a rating instrument that examines students' perceptions of college classroom climate, as compiled by Hu [25]. With a Keiser–Meyer–Olkin test value of 0.923 and a Cronbach's α coefficient above 0.85 for all dimensions, it has been demonstrated to have good reliability and validity. The scale comprises 26 items: cohesion (six items), supportability (six items), participation (four items), planning (five items), and fairness (five items). Responses were scored on a 5-point Likert scale ranging from 1 = "strongly disagree" to 5 = "strongly agree." The total score of the CCCA measurement tool ranges from 26 to 130 points, with higher scores indicating that students perceive a positive classroom climate. The Cronbach's α coefficient of the CCCA in this study was 0.87.

2.4.3. The Chinese version of the Competency Inventory for Nursing Students

The CINS was developed by Hsu and Hsieh [5] to measure nursing students' competency. This study used a modified and validated Chinese version of the CINS with a Cronbach's α coefficient of 0.966 [26]. In this study, the Cronbach's α coefficient of the CINS-CV was 0.97. The CINS-CV comprises 38 items and includes ethics and responsibility (14 items), clinical biomedical science (five items), general clinical skills (six items), critical thinking reasoning (three items), care (five items), and lifelong learning (five items) sub-dimensions. Responses were scored on a 7-point Likert-type scale ranging from 1 = "completely incompetent" to 7 = "completely competent." The aggregate CINS-CV score ranged between 38 and 266, with higher scores indicating stronger nursing student competency.

Table 1
The in-class teaching process of the nurse-faculty collaborative mini-CEX teaching model.

Teaching-learning process	Teachers' activities	Students' activities
Scenario creation (10 min)	Introduction of the clinical case and learning tasks at each phase of mini-CEX to the students.	a. Familiarization with the clinical case. b. Clear the learning tasks. c. Group division of labor.
Inquiry-based learning (30 min)	a. Describe the main ideas and challenges of learning for students. b. Encouraging students to apply clinical reasoning while analyzing clinical scenarios.	The learning groups complete each phase of the mini-CEX learning tasks through the following activities: a. Case discussion. b. Access to information. c. Asking questions of the teachers.
Case report (30 min)	Explain, supplement, correct, and evaluate the students' case reports.	Report case and evaluate inter-group performance based on the learning tasks of each stage in mini-CEX.
Scenario simulation exercise (40 min)	a. Show the operation video b. Demonstrate the operation c. Guided scenario simulation exercises	a. Watch videos and teacher demonstrations b. Practice operations c. Role play
Effectiveness evaluation (10 min)	Evaluation and feedback on the performance of the learning groups.	Mutual and self-evaluation, and propose improvements based on others' suggestions.

Note: mini-CEX = mini-clinical evaluation exercise.

2.4.4. Course achievement

The Fundamentals of Nursing course achievement included theoretical, operational, and scenario drill examination scores. The theoretical score is weighted such that 40% is derived from the scores of the two-stage examinations and 60% from the final examination scores. Two staged examinations were held in the last week of the first semester and in the seventh week of the second semester to evaluate the effectiveness of the students' theoretical studies in the previous stage. The final examination was performed within a week of the completion of the course. Examinations were conducted according to the rules of the examination subjects of the Academic Affairs Office of the school. They thus contained multiple-choice, short-answer, and case analysis questions, and the difficulty coefficient was controlled at approximately 0.7. The full and passing scores were 100 and 60, respectively. The operational examination score comprised the average scores of each examination. The assessment was performed in accordance with the requirements and scoring standards for each operation assessment. The full score for each operation was 100, and the passing score was 85. The score of the scenario simulation is the average score of each case scenario simulation examination at the end of each term. Students are required to solve patients' most urgent nursing problems through teamwork within a specified period. The unified scoring standard was 100 points.

2.4.5. Open-ended question

The open-ended question was, "What difficulties or challenges have you encountered in the classroom learning of the nurse-faculty collaborative mini-CEX teaching model?".

2.5. Data collection

Before the intervention, the teacher introduced the course content and the main process and purpose of the nurse-faculty collaborative mini-CEX teaching model to students. We created an electronic questionnaire through "Wenjuanxing" (https://www.wjx.cn/), which consisted of the general information questionnaire, the CCCA, and the CINS-CV. Participants in the intervention and control groups completed the questionnaire at baseline and end of the study (pre- and post-tests). In addition, an open-ended question was also collected through "Wenjuanxing." Furthermore, the course achievements of the participants were used to objectively assess teaching effectiveness.

The quality of the questionnaire was ensured by setting the time to complete it online, the number of times it was submitted, and the criteria for submission. We sent an electronic questionnaire and survey instructions to the social media group and explained the purpose and method of completing the questionnaire in detail. Additionally, we informed the students that the survey was anonymous and would only be used for teaching research to ensure they completed the questionnaire accurately.

2.6. Data analysis

The questionnaire survey data were statistically analyzed using SPSS version 20.0. Continuous variables were described by mean and standard deviation, and categorical variables were described by frequency and percentage. The chi-square test and *t*-test were used to compare the two groups. A difference considered statistically significant at $P < 0.05$ was taken into consideration. A frequency analysis table was generated using "Wenjuanxing" to analyze the open-ended questions. Subsequently, answers with similar meanings were grouped to extract keywords. Views were summarized and classified according to keywords, and themes were extracted.

3. Results

3.1. Characteristics of students

One hundred twelve nursing students were recruited for this study, and one withdrew for health reasons. A total of 111 students were divided into the intervention ($n = 56$) and the control ($n = 55$) group. There was no statistically significant difference between the general information of two groups ($P > 0.05$) (Table 2). Additionally, no significant differences were found in the CCCA ($P = 0.336$) and CINS-CV ($P = 0.858$) scores between the two groups before the intervention. (Table 3)

3.2. Effects of learning between the two groups

Following the intervention, there were differences in the CINS-CV ($P < 0.001$) and CCCA ($P = 0.008$) scores between the intervention and control groups (Table 2). In terms of course achievement results, the intervention group's theoretical exam score (83.01 ± 4.27 vs. 79.75 ± 5.45, $t = 3.511$, $P = 0.001$) and scenario simulation exam score (89.23 ± 3.17 vs. 81.42 ± 7.19, $t = 7.425$, $P < 0.001$) were higher than the control group, but there was no statistically significant difference in operational exam score (91.42 ± 1.74 vs. 91.65 ± 2.54, $t = -0.552$, $P = 0.582$). (Table 3)

Table 2
Comparison of the pre-intervention data of the two groups.

Variables	Total ($n = 111$)	Intervention group ($n = 56$)	Control group($n = 55$)	t/χ^2	P
Gender				0.370	0.543
Male	14 (12.6)	6 (10.7)	8 (14.5)		
Female	97 (87.4)	50 (89.3)	47 (85.5)		
Habitual residence				0.004	0.950
Rural area	77 (69.4)	39 (69.6)	38 (69.1)		
City	34 (30.6)	17 (30.4)	17 (30.9)		
Professional attitude				0.147	0.929
Dislike	9 (8.1)	4 (7.1)	5 (9.1)		
General	90 (81.1)	46 (82.2)	44 (80)		
Like	12 (10.8)	6 (10.7)	6 (10.9)		
Grade of basic medical courses				0.256	0.880
Qualified and below	7 (6.3)	3 (5.4)	4 (7.3)		
Moderate	105 (94.6)	48 (85.7)	47 (85.4)		
Excellent	9 (8.1)	5 (8.9)	4 (7.3)		

Note: Data are *n* (%). CCCA = College Classroom Climate Assessment Scale. CINS-CV = The Chinese version of the Competency Inventory for Nursing Students.

Table 3
Comparison scores of CINS-CV, CCCA in both groups and differences between the pre-test and post-test assessments.

Variables	Intervention group($n = 56$)	Control group ($n = 55$)	t	P
CINS-CV				
Pre-test	186.09 ± 26.52	185.15 ± 28.76	0.180	0.858
Post-test	208.36 ± 23.25	190.60 ± 28.83	3.812	< 0.001
t	−3.810	−0.816		
P	< 0.001	0.418		
CCCA				
Pre-test	96.73 ± 12.84	94.49 ± 11.55	0.966	0.336
Post-test	106.95 ± 14.48	99.55 ± 14.60	2.681	0.008
t	−4.993	−1.933		
P	< 0.001	0.058		

Note: Data are *Mean±SD*. CINS-CV= Chinese version of the Competency Inventory for Nursing Students. CCCA= College Classroom Climate Assessment Scale.

3.3. Difficulties or challenges encountered by students in the intervention group

Thirty-two nursing students reported varied difficulties and challenges, while the other students in the intervention group reported none. Four main challenges were identified in the learning process of the intervention group, included case understanding, group cooperation, tutor guidance, and acquisition of learning materials. (Table 4)

4. Discussion

As a backup force for nursing professionals, the core competencies of undergraduate nursing students are directly related to the stability of the nursing team and the level of clinical nursing quality. As a result, developing nursing students' core competences has emerged as a critical teaching aim and research priority for nursing educators. Following the implementation of the nurse-faculty collaborative mini-CEX teaching model, the intervention group's CINS-CV score was higher than the control group's ($P < 0.001$), demonstrating that the model had an effect on improving nursing students' core competencies. These results were higher than nursing students' competency (199.62 ± 4.53 vs. 187.51 ± 7.55) after the intervention of a hybrid teaching model based on interaction and cognitive engagement reported by Zhang et al. [27]. This finding is similar to that of Lee [28] and Liu et al. [29], who studied the effects of team-based learning and case-based teaching on undergraduate nursing students' competency. Thus, teaching strategies are influential factors in determining nursing students' competency. Motefakker et al. [30] reported that applying the mini-CEX to nursing teaching positively impacted students' clinical competence and professionalism. Moreover, Pedregosa et al. [31] concluded that a cooperative teaching mode is effective in nursing education. Collaborative teaching between educational and health institutions can successfully promote clinical learning, thus improving nursing students' competency. From the perspective of

Table 4
Difficulties or challenges encountered by students in the intervention group ($n = 56$).

Factors	Detail	*n* (%)
Case analysis		22 (39.3)
	Insufficient clinical logical thinking	11 (19.6)
	Inability to detect health problems in cases	8 (14.3)
	Unfamiliar with theoretical knowledge	3 (5.4)
Group cooperation		15 (26.7)
	Unclear division of work in the group	5 (8.9)
	Group members have a bystander mentality	4 (7.1)
	Uncomplete the scenario simulation exercise within the specified time	6 (10.7)
Acquisition of learning materials	Lack of access to learning resources	5 (8.9)
Teacher guidance	Shortage of teachers' guidance	4 (7.1)

nursing students' competency, our research offers several possible explanations for the effectiveness of the nurse-faculty collaborative mini-CEX teaching model in the *Fundamentals of Nursing*. First, co-teaching by nursing faculty and clinical nursing experts based on clinical nursing cases can motivate students to integrate theoretical knowledge with clinical nursing practice and develop logical thinking. Additionally, the content of each stage of the mini-CEX was completed in the form of a role-play and a case report, which was compatible with clinical nursing procedures, enabling nursing students to exercise and improve their knowledge, skills, communication, teamwork, and humanistic care [30]. In conclusion, the results of our study support the nurse-faculty collaborative mini-CEX teaching model in nursing education as an effective way to enhance nursing students' competency.

Classroom climate is a comprehensive state of the psychological, emotional, and social climate between teachers and students, which plays a pivotal role in classroom behavior and teaching quality [32,33]. This study investigated participants' perceptions of the classroom atmosphere. The results demonstrated that nursing students' perceptions of the classroom climate in the intervention and control groups were moderate to high after the intervention, which was higher than the middle level found by Kurt et al. [34] among 134 nursing students. This shows that the nursing students in our study better perceived the classroom atmosphere. However, students' age, degree of learning, and instructional strategies could contribute to these differences. The findings also revealed that students in the intervention group performed better on the score of the CCCA than the control group ($P = 0.008$). Teachers release teaching cases, learning tasks, and related learning materials to students before class in the nurse-faculty collaborative mini-CEX teaching model, which helps them understand the learning objectives, comprehend the classroom teaching content, and better arrange the learning process according to the teaching plan, thus improving cohesiveness in the classroom climate. Scenario simulation and roleplay can stimulate students' interest in active inquiry learning and classroom attention in the classroom teaching process. Kim et al. [35] concluded that simulation-based nursing teaching interventions have a strong educational effect, particularly in the psychomotor domain of students. Specifically, the closer the contextual simulation teaching is to actual work, the higher the students' interest in learning and motivation for classroom discussions. Student-centered teaching practices, including team-based learning, debate, simulation, and inquiry-based instruction, are associated with specific components of open classroom climate and academic performance [36–38]. Team-based learning was applied in our teaching mode. Students learned in small groups to present ideas and discuss and explain solutions to problems. Teachers gave students fair opportunities to express their opinions, participate in discussions, and conduct mutual evaluations. Team-based learning positively affected nursing students' perceptions of the classroom's psycho-social climate. Our findings support the idea that the nurse-faculty collaborative mini-CEX teaching model is conducive to a positive, harmonious, and open classroom climate.

This study's results demonstrated that the scores of the theoretical and scenario simulation exams of students in the intervention group were higher than the control group ($P < 0.01$), and the operational exam scores of both groups were at a higher level (91.42 ± 1.74 vs. 91.65 ± 2.54). Clinical scenario simulation exercises required students to obtain better theoretical knowledge and clinical skills and set higher requirements for their teamwork, clinical thinking, and communication skills [39,40]. In the mini-CEX teaching model, cooperation between nursing college faculty and clinical nursing experts in case teaching largely avoided the disconnection between theory, skill teaching, and clinical work practice. Moreover, scenario simulation, group learning, and role-play in the teaching model improved students' critical thinking ability and clinical thinking logic, enabling them to flexibly use theoretical knowledge and clinical thinking to solve clinical nursing problems in theory exams and functional exercises. Research has shown that simulation-based education and team- and case-based learning significantly improve students' academic performance, professional skills, clinical decision-making ability, and critical thinking [41–44]. In general, our research results support the idea that the nurse-faculty collaborative mini-CEX teaching model is conducive to improving the teaching quality of Fundamentals of Nursing course and the course achievement of nursing students.

According to the results of the open-ended questions, 57.1% of the students reported different types of difficulties or challenges, with case comprehension issues being the most common (39.4%). Case-based learning aims to motivate students to develop a multifaceted ability to transfer their knowledge to clinical nursing work to identify and solve complex health problems [45,46]. As some students needed more clinical thinking and knowledge base, it was difficult to identify valid information and relate it effectively to what they had learned. Additionally, 8.9% and 7.1% of students gave feedback on needing more learning resources and timely teacher guidance. Based on our findings, teachers should highlight effective information in specific cases, set more guiding questions, and provide multiple ways to access learning resources for students in the early stage. Additionally, 26.7% of the students mentioned problems related to group cooperation, mainly reflected in the unreasonable distribution of tasks among group members, the low motivation of some students, and the problem of overtime owing to unskilled operations. Therefore, we suggest that teachers assist in group task assignments in the early stages, release teaching videos before class to help students preview relevant nursing operations, and open the training room before and after class to provide practice spaces and materials for students.

5. Limitations

Our study has several limitations. First, the students in the intervention and control groups were from the same year at the same college; thus, the risk of contamination could not be completely excluded. Second, some limitations may exist in the representativeness of the study results, as the sample size, study time, and other factors may have influenced this study. Finally, the application of the nurse-faculty collaborative mini-CEX teaching model requires teachers to have strong case writing and classroom organizational skills and extensive clinical nursing experience, which directly affects the quality of teaching and students' learning experience [47]; however, these were the main challenges and difficulties encountered by nursing teachers in college and clinical nursing specialists from the affiliated hospitals in this study. The teaching mode in this study may also affect other aspects of students (e.g., learning interest, satisfaction, and professional self-concept), and virtual simulation technology may be tried in the class. Therefore, further studies are warranted.

6. Conclusion

This study confirmed a method for improving nursing students' competency and course achievement and building a positive and open classroom climate using the nurse-faculty collaborative mini-CEX teaching model. Therefore, we recommend increasing nursing students' participation in teamwork, simulation exercises, and case discussions using active teaching methods. The nurse-faculty collaborative mini-CEX teaching model is recommended as a highly interactive method in nursing curricula.

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Data availability statement

The datasets generated during and analyzed during the current study are available from the corresponding author upon reasonable request.

CRediT authorship contribution statement

Yangguang Chen: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Project administration. **Xiaomang Li**: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - review & editing, Supervision, Project administration. **Jia Zhao**: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - review & editing. **Shenmei Li**: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Writing - review & editing. **Yunyun Dai**: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Writing - review & editing. **Zili Zhou**: Conceptualization, Methodology, Validation, Formal analysis, Funding acquisition, Writing - review & editing, Supervision, Project administration.

Declaration of competing interest

The authors declare that they have no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnss.2023.06.013.

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