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The Application of CDIO-Based CBL Teaching Model in the Clinical Teaching of Operating Room Nursing: A prospective controlled study

Huiqin Li
The Fourth Hospital of Hebei Medical University
Shanshan Zhang
The Fourth Hospital of Hebei Medical University
Shujun Li
The Fourth Hospital of Hebei Medical University
Fengxia Liu
The Fourth Hospital of Hebei Medical University
Junjie zhou
15633886687@163.com
The Fourth Hospital of Hebei Medical University

Research Article

Keywords: CDIO teaching model, CBL teaching model, Operating room, Nursing interns

Posted Date: April 9th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9058626/v1

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Additional Declarations: No competing interests reported.

Abstract

Background/Aim:

Traditional teaching methods in operating room nursing education may not fully develop the integrative clinical thinking and self-directed learning skills required in modern practice. Innovative pedagogical models combining structured engineering approaches (CDIO) with CBL have been proposed to bridge this gap. The study aimed to assess the effectiveness of a conceive-design- implement-operate (CDIO)-based case-based learning (CBL) model on the clinical teaching of operating room nursing interns.

Methods

A prospective controlled study included nursing interns at a tertiary hospital from June 2023 to June 2024. Fifty undergraduate nursing interns who were assigned to the operating room in June 2023 comprised the control group, while another 50 interns in the same department in June 2024 were assigned to the observation group. The observation group received the CDIO-based CBL teaching model, whereas the control group followed the traditional teaching. After four weeks, effectiveness was evaluated by comparing theoretical knowledge, clinical practical skills, self-directed learning (SDL) ability, clinical thinking ability, teaching quality, and teaching satisfaction between the two groups.

Results

Compared with the scores of the interns in the control group, the theoretical and clinical practice skills scores of the interns in the observation group significantly improved ($P < 0.05$). In the evaluation of SDL ability and clinical thinking ability, the scores of the control group were lower than those of the observation group, with a statistical difference ($P < 0.05$). For the intervention group, the teaching quality and teaching satisfaction scores were significantly higher than those of the control group ($P < 0.05$).

Conclusions

The CDIO-based CBL teaching model in nursing interns education for the operating room can effectively improve assessment scores, SDL ability, and clinical thinking ability, while elevating the quality of teaching, ensuring scientific rigor, rationality, and practicality.

Introduction

In recent years, higher medical education has flourished. Its sustained high-quality development is the foundation for ensuring the cultivation of an adequate number of high-level medical talents [1]. Under the background of the development of new medicine, optimizing the teaching process, constructing a teaching model that comprehensively cultivates knowledge, ability and quality, and enhancing students'

professional quality and comprehensive thinking ability have become an inevitable requirement for the development of undergraduate education in nursing [2]. Clinical teaching, as a key link in nursing professional education, serves as an important bridge for consolidating theoretical knowledge and cultivating clinical nursing thinking. Effective clinical teaching can help students develop professional skills [3], deepen their knowledge reserves and improve their proficiency in clinical operations. Nursing interns also undertake important clinical work, including ward duty, injection and infusion therapy, and surgical cooperation. They have to deal with high-intensity workloads, irregular schedules and the huge pressure of handling sudden clinical events. Therefore, it is of vital importance to master clinical theoretical knowledge and nursing operation skills proficiently. However, the traditional single teaching mode often fails to effectively stimulate students' enthusiasm for autonomous learning, which is not conducive to the systematic improvement of their clinical practice ability, thinking and judgment ability, and comprehensive quality [4]. Therefore, it is necessary to actively explore innovative paths for clinical nursing education and build a teaching system centered on students that fully stimulates their interest in autonomous learning.

As the core technical department of a hospital, the operating room has highly specialized nursing work, complex technical operations, high requirements for teamwork, and variable emergency situations [5, 6]. Clinical practice is a crucial transitional stage for nursing students from theory to practice, and it is also an important bridge connecting theoretical learning with the cultivation of professional abilities [7]. The teaching quality at this stage is directly related to the future patient safety, surgical outcomes, and the professional identity of the nursing students themselves. Clinical teaching in operating rooms traditionally followed a "master-apprentice" model. However, the unique environment and demands of operating rooms, including diverse knowledge, advanced skills, aseptic techniques, and fast-paced work, pose challenges for nursing students. The conventional teaching approach can lead to student passivity, difficulty in adaptation, and slower knowledge and skill acquisition. [8]. Therefore, strengthening the collaboration between medical care and education and enhancing the quality and effectiveness of clinical practice teaching have become important issues currently faced by medical education.

Case-Based Learning (CBL), as an open and interactive teaching strategy, takes real clinical cases as clues to guide students to actively explore and solve problems [9]. It takes into account the integration of clinical operation training and theoretical knowledge, and its core lies in cultivating students' clinical thinking and comprehensive analysis ability. Compared with traditional teaching methods, CBL can more effectively cultivate students to become versatile professionals in the clinical field [10–11]. For instance, it has been applied in research misconduct teaching [12], psychology teaching [13], and dental education [14]. The Conceive-Design-Implement-Operate (CDIO) education model was initially proposed by four universities including the Massachusetts Institute of Technology in 2004 [15]. It is an engineering education model that emphasizes systematic thinking, practical ability and continuous improvement. This model emphasizes students' subjectivity, the unity of theory and practice, as well as the cultivation of cooperative and autonomous learning [16]. Its structured and project-based characteristics are highly consistent with the process-oriented and collaborative nature of operating room nursing work. In recent years, the application of CDIO in medical vocational education has become increasingly widespread.

Compared with traditional teaching methods, it has shown significant advantages in nursing students arrhythmia education [17].In recent years, the teaching model combining CDIO and CBL has demonstrated synergy in multiple medical and nursing fields. Research shows that in orthopedic nursing teaching, the CBL within the CDIO can significantly enhance students' knowledge and skills [18].

Methods

Study design

A prospective controlled experimental design was employed in this study.

Participants

Convenience sampling was used to select undergraduate nursing interns from the 2023 and 2024 cohorts who were completing their clinical internshipin the operating room of a tertiary hospital. After excluding six interns who did not complete the full program, the final sample comprised 100 interns. Fifty undergraduate nursing interns who were assigned to the operating room in June 2023 comprised the control group (9 males, 41 females, mean age 21.26 ± 1.05 years), while another 50 interns in the same department in June 2024 were assigned to the observation group (11 males, 39 females, mean age 21.14 ± 0.88 years). All participants provided informed consent and met the inclusion criteria: being undergraduate nursing interns, experiencing their first operating room placement, and providing signed consent. Exclusion criteria included an inability to participate fully in the clinical practice. No significant differences were found in baseline data between the two groups ($P > 0.05$), ensuring comparability.

Teaching Methods

Both groups completed a four-week clinical internship within the operating room. The teaching content was based on the *Operating Room Nursing Practicum Syllabus* and included both theoretical knowledge and clinical practical skill components. Instructors in both groups had comparable qualifications, and a designated teaching nurse was responsible for overall teaching quality control.

Control Group

The control group received instruction following the traditional apprenticeship-style teaching model. During the first week, intensive instruction was provided, covering theoretical knowledge of the operating room environment, protocols, aseptic techniques, and demonstrations of basic operations. From the second to the fourth week, students were randomly assigned to different operating suites. Under the guidance of their assigned clinical instructors, they primarily observed and assisted with clinical procedures as the instructors demonstrated operating room workflows. Assessments were conducted three days prior to the conclusion of the interns’ practicum in the department.

Intervention Group

The intervention group received instruction using a CDIO-based CBL teaching model. We designed a corresponding learning plan and schedule based on the four phases of CDIO. The specific implementation steps included the following: During the first week, the teaching content mirrored that of the control group. For the second to the fourth weeks, practical skill instruction utilized the CDIO-based CBL teaching model, encompassing a total of 40 class hours. Assessment and evaluation were conducted three days prior to the conclusion of the practicum.

Step 1: Formation of the Teaching Team and Development of the Plan

A dedicated project team was established, led by the operating room head nurse and comprising four teaching instructors, each with over three years of clinical nursing practicum teaching experience. This team was responsible for the effective distribution and centralized management of teaching information and feedback. Two weeks prior to the commencement of the teaching program, the team leader conducted a collective training session for all instructors. This training covered the core concepts, theoretical foundations, implementation procedures, and key considerations of the integrated CDIO-CBL model, with provision for consultation with experts on challenging issues. In alignment with the requirements of *Adult Nursing and the practicum syllabus*, the team collaboratively formulated the overall teaching objectives, developed the master teaching plan, and conducted collective lesson preparation.

Step 2: Formulation of Three-Dimensional Teaching Objectives

Guided by the internship training syllabus and with reference to the CDIO talent training syllabus and standards[19], and considering the specific characteristics of operating room nursing education, three-dimensional teaching objectives were defined for the nursing interns: (1) Knowledge Objectives: To master fundamental professional knowledge and related systemic processes in the operating room. This dimension corresponds to the "Technical Knowledge and Reasoning" component of the CDIO syllabus. (2) Ability Objectives: To enhance basic professional skills, critical thinking, and self-directed learning abilities. This aligns with the "Personal and Professional Skills and Attributes" component of the CDIO syllabus. (3) Quality Objectives: To foster correct professional values and a spirit of humanistic care. This objective maps to the "Interpersonal Skills: Teamwork and Communication" component of the CDIO syllabus.

Step 3: Development of the CDIO-CBL Teaching Plan

C1 (Conceive): Teaching Conception

This stage comprises of 8 class hours. Within this stage the multidimensional teaching goals and planned content—encompassing knowledge (e.g., OR protocols, fundamental nursing content, intraoperative coordination, intraoperative precautions), skills (e.g., surgical hand antisepsis, instrument passing, patient positioning), and attitudes (e.g., integrity, team awareness, communication skills) to be achieved post-instruction. The teaching lead and instructors developed a targeted teaching plan, selecting typical surgical cases (e.g., laparoscopic cholecystectomy, total hip arthroplasty, intracranial tumor resection). Students were guided to preview and research theoretical knowledge related to the cases, such as anatomy, physiology, surgical steps, and key nursing points, and collaboratively completed the preliminary conception of the nursing care plan for the selected surgery.

D2 (Design): CBL Task Design

This stage comprises of 4 class hours. Cases were chosen to cover diverse surgical specialties, approaches, and nursing priorities to ensure comprehensive competency development. Students were actively guided to identify key coordination phases and potential risks through case analysis. Instructors designed specific, actionable task lists focused on nursing assessment, diagnosis, and implementation (e.g., donning sterile attire, preparing instruments, establishing IV access, managing surgical counts). For instance, for a laparoscopic cholecystectomy, tasks included analyzing how to establish pneumoperitoneum and manage signs of subcutaneous emphysema. Students completed these tasks by consulting resources and watching procedural videos. Instructors designed differentiated tasks based on student competency levels, employing strategies such as group discussions and plan presentations.

I3 (Implement): CBL Teaching Implementation

This stage comprises of 24 class hours and primarily consists of two core activities: (1) Interactive Seminars and Discussion: Students analyzed, summarized, and synthesized the nursing knowledge involved in the case studies. Interactive sessions with instructors were conducted through mini-lectures, teaching rounds, health education discussions, and case analyses. Instructors facilitated in-depth interactive discussions among all students focusing on key knowledge points (e.g., aseptic field demarcation, safe use of electrocautery), critical procedural links (e.g., surgical specimen management, intraoperative count protocol), and challenging issues (e.g., responding to sudden equipment failure). At the end of each session, instructors provided commentary, summarized key points, gave timely feedback, and adjusted teaching strategies proactively to ensure student comprehension and retention. (2) Scenario Simulation Training: Scenario simulation training constituted a core component of the implementation phase, encompassing three structured formats to develop comprehensive competency. Specialty process simulation involved full-process surgical coordination drills, conducted in a simulated environment, which guided students through sequential steps from the preoperative visit to postoperative patient transfer. Immersive role-playing further deepened this experience by having students assume and rotate through key roles-such as scrub nurse and circulating nurse—within simulated surgeries, thereby fostering a practical understanding of team dynamics and individual responsibilities. Emergency situation simulation was designed to enhance crisis preparedness, providing

targeted training for critical scenarios like intraoperative massive hemorrhage or cardiac arrest, with a focused emphasis on emergency response protocols, resuscitation coordination, and the correct operation of medical equipment under pressure.

O4 (Operate): Teaching Operation and Evaluation

This stage comprises of 4 class hours.The teaching plan was systematically executed with integrated evaluation. Each student used an Operating Room Practicum Competency Handbook, listing required theoretical knowledge and skills assessed on a three-tier scale ("Mastered," "Proficient," "Familiar"). Instructors dynamically record students' performance and progress at each stage, providing timely personalized feedback and guidance. Upon completion of a teaching phase, instructors systematically summarize the key instructional content and organize students to complete immediate assessments, thereby reinforcing knowledge and enabling visual validation of learning outcomes. During the teaching interaction and continuous optimization phase, structured discussions are conducted based on assessment results and students' questions, with instructors offering centralized explanations and extended discussions to guide students in sharing practical observations and reflections. Drawing on interactive feedback and assessment data, instructors systematically analyze learning effectiveness, identify common weaknesses and individual differences, and formulate teaching improvement plans. This process allows for the dynamic adjustment of subsequent teaching strategies and content, thereby driving the continuous enhancement of teaching quality and the iterative refinement of the instructional model.

Observation Indicators

Theoretical knowledge and Clinical Practice Skill Assessment

Upon completion of the practicum, nursing students underwent a combined assessment of theoretical knowledge and clinical skills. Theoretical mastery was evaluated through a proctored, 90-minute written examination with a total score of 100 points. The test papers, designed by the teaching team, specifically focused on core operating room nursing knowledge, including but not limited to OR environment protocols, principles of aseptic technique, surgical instrumentation, patient safety and positioning, and roles of the surgical team. To ensure equitable assessment across the two cohorts interning in different years, questions were selected from a categorized question bank (easy, medium, hard) and structured to assess basic knowledge (30%), comprehension (30%), and comprehensive application (40%) of operating room principles. Two paper versions (A and B) of comparable difficulty were created, one of which was randomly administered to each student.

For the clinical skills assessment, conducted in the operating room simulation environment, students were randomly assigned to perform one key procedure from a standardized list. This list encompassed essential tasks such as surgical hand antisepsis and closed gowning/gloving, establishing and maintaining a sterile field, instrument identification and passing for a specified surgery, safe patient

positioning, and managing the surgical count protocol. Each procedure was evaluated against detailed, standard criteria with a total possible score of 100 points, allocated across critical steps and performance quality. To ensure objectivity and fairness, performances were rated independently by two qualified instructors.

Self-directed Learning Ability Evaluation Scale

Self-directed learning ability was assessed three days before the end of the four-week practicum using the scale developed by Zhang Xiyan [20]. The scale includes 30 items grouped into four dimensions: learning motivation (8 items), self-management ability (11 items), learning cooperation ability (5 items), and information literacy (6 items). Each item is rated on a 5-point Likert scale from 1 (“completely inconsistent”) to 5 (“completely consistent”). The total score ranges from 30 to 150, with higher scores reflecting stronger self-directed learning ability. In the present sample, the scale showed good internal consistency (Cronbach’s $\alpha = 0.822$).

Primary Trait Analysis (PTA) Assessment of Clinical Thinking Skills

Clinical thinking ability was assessed using the Primary Trait Analysis (PTA) scale, which evaluates multiple dimensions including logical, systematic, evidence-based, critical, imaginative, network, vertical, and lateral thinking. To precisely capture competency levels and address noted declines in clinical thinking skills, a 3-point Likert scoring method was employed for each trait [21]. For instance, in logical thinking, a score of 3 indicated proficient sequencing in clinical practice; a score of 2 denoted understood but limitedly applied sequencing; and a score of 1 represented basic ability. This method allowed for the calculation of score distributions and mean scores per indicator.

Teaching Quality Evaluation

In the fourth week, a teacher-student symposium and teaching quality evaluation were conducted the day before leaving the department. The teaching quality evaluation form, designed by Zhou Tong [22], includes five aspects: teaching attitude, teaching content, teaching methods, teaching effectiveness, and teaching characteristics. Responses were recorded on a Likert 5 scale, with higher scores indicating better perceived teaching quality. The evaluation was completed after the specialized internship. The questionnaire showed good reliability, with a Cronbach's alpha coefficient of 0.85 for the scale.

Teaching Satisfaction Evaluation

The teaching satisfaction of the two groups was evaluated using a questionnaire[23]. A total of 100 valid questionnaires were collected. The self-designed questionnaire assessed satisfaction across multiple domains: enhancing independent learning ability, stimulating learning interest, cultivating team spirit, improving practical skill level, strengthening comprehensive competence, improving doctor-patient communication skills, and development of clinical thinking ability. The questionnaire's reliability and validity have been tested. The overall Cronbach's alpha coefficient was 0.917, the split-half reliability coefficient was 0.819, and the coefficients for subscales ranged from 0.712 to 0.843. These results

indicate high internal consistency for both the overall questionnaire and its subscales, meeting relevant psychometric standards. The survey was administered upon completion of the four-week practicum.

Data analysis

Data were analyzed using SPSS (version 23.0). Continuous variables were presented as mean ± standard deviation ($\bar{x} \pm s$) and compared between groups using the independent samples t-test. Categorical data were expressed as frequency and percentage [n (%)] and analyzed using the chi-square test or Fisher's exact test, as appropriate. A two-sided $P < 0.05$was considered statistically significant.

Results

The average score of theory for the observation group (87.88 ± 5.03) was significantly higher than that of the control group (80.52 ± 7.54) (t = 4.180, $P < 0.001$). The average score of skill assessment of the observation group (92.32 ± 0.66) was significantly higher than that of the control group (84.17 ± 0.63) (t = 63.131, $P < 0.001$) (Fig. 1).

Comparison of scores of self-directed learning ability scores of nursing interns in the two groups are shown in Table 1. The difference was statistically significant between groups ($P < 0.001$).

Table 1
Comparison of Self-directed learning ability evaluation scale between two groups of nursing students (M ± SD, score)

Variable	Control group (n = 50)	Observation group (n = 50)	*t* value	*P* value
learning motivation	26.18 ± 1.41	32.48 ± 1.20	-24.01	< 0.001
self management ability	35.82 ± 1.72	42.36 ± 1.012	-22.51	< 0.001
learning cooperation ability	14.60 ± 0.97	18.98 ± 0.80	-24.71	< 0.001
information literacy	18.12 ± 0.90	20.82 ± 0.87	-20.92	< 0.001

In the evaluation of clinical thinking ability, the scores of the control group were lower than those of the observation group, with a statistical difference ($P < 0.05$, Table 2).

Table 2
Comparison of clinical thinking ability PTA between the two groups of nursing students (M ± SD, score).

Variable	Control group (n = 50)	Observation group (n = 50)	*t* value	*P* value
Logical thinking	1.64 ± 0.63	2.30 ± 0.58	-5.44	< 0.001
Systematic thinking	1.64 ± 0.56	2.30 ± 0.58	-5.77	< 0.001
Vidence-Based Thinking	1.66 ± 0.52	2.04 ± 0.53	-3.61	< 0.001
Critical thinking	1.60 ± 0.57	2.00 ± 0.53	-3.61	< 0.001
Imaginative thinking	1.98 ± 0.43	2.30 ± 0.65	-2.92	0.005
Network thinking	1.98 ± 0.43	2.20 ± 0.64	-2.02	0.046
Vertical thinking	1.96 ± 0.40	2.34 ± 0.63	-3.61	< 0.001
Lateral thinking	2.00 ± 0.49	2.52 ± 0.71	-4.26	< 0.001

The teaching quality evaluation results of the two groups showed that the total score of the observation group (96.72 ± 1.47) was significantly higher than that of the control group (92.94 ± 1.97), and the difference was statistically significant (t = − 10.86, $P < 0.001$). Furthermore, the observation group scored higher than the control group in all five other dimensions (Table 3).

The nursing interns in the observation group had significantly better teaching satisfaction than the control group ($P < 0.001$, Table 4).

Table 3
Comparison of teaching quality between the two groups of nursing students (M ± SD, score).

Variable	Control group (n = 50)	Observation group (n = 50)	*t* value	*P* value
Teaching Attitude	18.56 ± 0.81	19.58 ± 0.79	-6.29	< 0.001
Teaching Content	18.38 ± 0.81	19.20 ± 0.50	-6.13	< 0.001
Teaching Method	18.62 ± 0.88	19.28 ± 0.73	-4.09	< 0.001
Teaching Effect	18.64 ± 0.85	19.18 ± 0.72	-3.43	0.001
Teaching Feature	18.74 ± 1.18	19.48 ± 0.84	-3.63	< 0.001
Total Score	92.94 ± 1.97	96.72 ± 1.47	-10.86	< 0.001

Table 4
Comparison of teaching satisfaction between the two groups of nursing students (M ± SD, score).

Variable	Control group (n = 50)	Observation group (n = 50)	χ^2 value	*P* value
Enhancing independent learning ability	26 (52.00)	42 (84.00)	11.76	< 0.001
Improving learning interest	27 (54.00)	42 (84.00)	10.52	0.001
Increasing teamwork	24 (48.00)	44 (88.00)	18.38	< 0.001
Cultivating clinical thinking ability	23 (46.00)	44 (88.00)	19.95	< 0.001
Improving practical operations level	26 (52.00)	46 (92.00)	19.84	< 0.001
Improving comprehensive quality	23 (46.00)	45 (90.00)	χ22.24	< 0.001
Improving doctor-patient communication ability	20 (40.00)	43 (86.00)	22.69	< 0.001

Discussion

This study evaluated the effect of applying the CDIO-based CBL teaching model to the teaching of undergraduate nursing interns. A total of 100 students received clinical teaching and completed the assessment.

The demographic data of the observation group and the control group are comparable. The CDIO-based CBL teaching model increased the theoretical and clinical skills scores of interns by 9.1% and 9.7%, respectively, compared with the traditional teaching mode. The levels of self-directed learning ability, clinical thinking ability, teaching quality, and teaching satisfaction in the observation group were significantly higher than those in the control group ($P < 0.05$). In this study, the CDIO teaching model was introduced for the first time into the practical skills training of operating room nursing. The gender ratio of the two groups of students was balanced, minimizing the influence of potential confounding factors to the greatest extent. To enhance the consistency and reliability of the assessment and reduce differences among assessors, all assessment items are jointly completed by four assessors who have received unified training.

Medical education is currently undergoing a gradual and profound transformation to meet the new requirements of the medical and health care industry and talent cultivation [24]. Globally, medical education programs are increasingly emphasizing the diversified development of teaching forms and contents [25]. Over the past few decades, various university education models have been developed to

better align with teaching objectives, cultural backgrounds, and students' autonomous learning needs [26–27]. Research shows that the CBL model effectively drives students to actively complete the entire exploration process of case information analysis, differential diagnosis, and treatment planning by presenting real clinical situations, thereby significantly enhancing their learning engagement and clinical reasoning ability [28–29]. The CDIO model focuses on enabling students to not only master a solid theoretical foundation but also possess the ability to apply knowledge to actual clinical situations [30]. In terms of teaching design, CBL focuses on conducting teaching through specific cases, while CDIO pays more attention to the entire process of training from project conception to practical operation. CBL can make up for the possible deficiencies of CDIO in solving open clinical problems and integrating interdisciplinary knowledge.

The operating room is a highly specialized and demanding workplace within a hospital, characterized by complex medical tasks, technical precision, and a fast-paced environment [31]. Therefore, it is of vital importance to cultivate in nursing students strong emergency response capabilities, the precision of instrument operation, and teamwork, as well as their concentration and execution ability in high-pressure environments.

The CDIO-based CBL teaching model designs learning tasks in a problem-oriented manner, guiding students to learn and master knowledge and skills by solving practical problems. This model guides students to independently explore and analyze through real cases, thereby enhancing their adaptability, psychological resilience, and stress coping ability. This study evaluated the effectiveness and applicability of this innovative teaching model in operating room education, especially in cultivating the theoretical knowledge, operational skills, self-directed learning ability, and clinical thinking ability of undergraduate nursing interns. Given its success, this teaching method has the potential to be promoted and applied to other clinical medical disciplines in the future.

The assessment of the abilities of undergraduate nursing interns has become a routine process, among which the objective Structured clinical Examination and clinical skills assessment are the most commonly used assessment methods in a simulated environment [32]. However, these tools mainly assess the ability performance in specific scenarios and are difficult to comprehensively reflect the comprehensive quality of students in complex clinical environments. In the fast-paced and demanding field of operating rooms, both nursing interns and their instructors are confronted with high-intensity workloads, leaving very limited time for systematic assessment and feedback. Therefore, this study adopted a comprehensive evaluation system covering theoretical examinations, clinical skills examinations, self-directed learning ability, clinical thinking ability, teaching quality, and teaching satisfaction. This multi-dimensional assessment approach aims to measure teaching effectiveness and student development more comprehensively, and is particularly suitable for the teaching environment of operating room nursing, where time is limited, but comprehensiveness is required.

Limitations

However, due to certain limitations, the findings of this study should be interpreted with caution. First, the sample size is relatively small and was drawn from a group of nursing interns at a single hospital, which reflects constraints related to time and conditions. Therefore, larger and multi-center studies are necessary to further investigate the applicability and educational impact of this teaching model in the clinical training of nursing professionals. Additionally, fostering nurses' autonomous learning abilities and critical thinking is a long-term endeavor. Future research should also address how to enhance the durability and stability of the research outcomes.

Conclusion

In summary, the CDIO-based CBL teaching model applied in the clinical education of operating room nursing interns significantly enhances theoretical knowledge and practical skills, while also strengthening students' self-directed learning abilities and clinical thinking. Compared with traditional teaching methods, this integrated model demonstrates clear advantages in improving overall teaching quality and student satisfaction. Moreover, the structured, practice-oriented nature of the CDIO framework ensures that the teaching process is not only scientifically sound but also highly applicable to real-world clinical settings. These findings support the broader implementation of the CDIO-based CBL model in nursing education, offering a promising approach to cultivating competent and reflective nursing professionals. Future applications may further validate its effectiveness across diverse clinical disciplines and contribute to the ongoing innovation of teaching strategies in nursing training programs.

Declarations

Ethics approval and consent to participate

The research was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of The Fourth Hospital of Hebei Medical University (Approval No. 2025KT332). Informed consent was obtained from all participants involved in this study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Funding

2022 Hebei Provincial Health Commission Medical Science Research Project

(20221357).

Author Contribution

Li Huiqin: Data analysis and Writing - Original Draft; Shanshan Zhang: Formal analysis; Shujun Li: Validation; Fengxia Liu: Data Curation;Writing - Review & Editing; Junjie Zhou: Conceptualization; Methodology;Writing - Review & Editing

Acknowledgement

The authors wish to acknowledge the contribution of all nursing interns who took part in the research and completed the questionnaire.

Data Availability

The data are available from the corresponding author upon reasonable request via Email.

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Figures

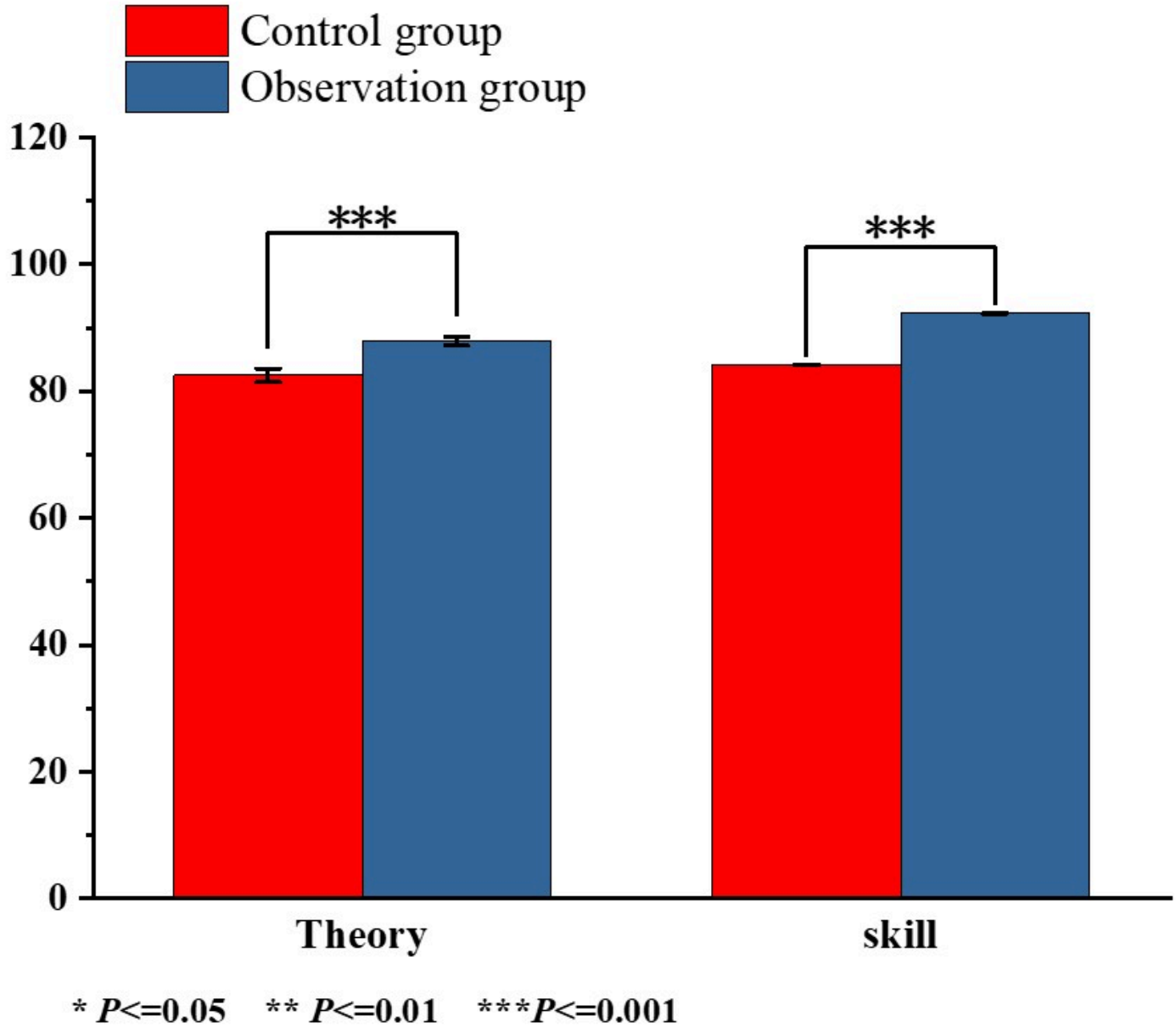


Figure 1

Comparison of theory and skill exams between the two groups