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Effects of a 3P Theory–Based Simulated Interprofessional Education on Nursing Students' Clinical Core Competencies: A Mixed-Methods Study

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Abstract

Although previous studies using single research methods have examined the impact of simulated interprofessional education (SIPE), a comprehensive understanding of its effects remains limited. Additionally, many studies lack a theoretical framework to guide teaching design, reducing methodological rigor. This study aimed to investigate the effects of a 3P theory–based SIPE model on the "Clinical Critical Thinking Training" course using a convergent mixed-methods approach, providing evidence to inform future educational strategies. A convergent mixed-methods design was employed, combining quantitative surveys and semi-structured interviews. Data were collected between September 2021 and July 2022. Using cluster sampling, 60 full-time nursing students from a Chinese university were randomly assigned to a control group (n = 36) or an experimental group (n = 24). To form interprofessional teams in the experimental group, six students from clinical medicine and six from pharmacy volunteered to participate. Both groups completed the "Clinical Critical Thinking Training" course, with the control group receiving traditional simulation instruction and the experimental group participating in SIPE. Quantitative outcomes were measured pre- and post-course using the California Critical Thinking Disposition Inventory (CCTDI) and the Assessment of Interprofessional Team Collaboration in Student Learning Scale (AITCS-II Student). Descriptive statistics and the Mann–Whitney U test were applied to compare critical thinking and interprofessional collaboration skills between groups. Qualitative data from semi-structured interviews were analyzed thematically to explore students' development of interprofessional competencies and learning experiences. Both groups showed improvements in critical thinking and interprofessional collaboration after the course; however, the experimental group demonstrated significantly greater gains compared to the control group ($p < 0.05$). Three main themes emerged from the qualitative analysis: clarifying team roles, enhancing team efficiency, and optimizing the overall learning experience. The 3P theory–based SIPE model effectively enhanced nursing students' critical thinking, teamwork, and interprofessional competencies, suggesting its value as a structured approach for interprofessional education.

Keywords: Interprofessional collaboration, Simulated interprofessional education, Critical thinking, Nursing education

Introduction

Simulation involves replicating or amplifying real-world experiences by reproducing essential elements of reality in an interactive environment [1]. Simulation-based teaching provides learners with an immersive and realistic learning experience, allowing for repeated practice, identification of errors, and personalized learning opportunities [2, 3].

Compared with traditional teaching methods, simulation has been shown to enhance clinical core competencies such as critical thinking; however, it is less effective at fostering collaborative skills [4].

Effective collaboration is essential for successful clinical practice, yet conventional simulation training often relies on single-role scenarios, limiting interdisciplinary cooperation and preventing the development of a clear interprofessional role identity [5].

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The delivery of safe and effective healthcare relies on the coordinated efforts of multiple health professions. Collaborative care, recognized as the gold standard, seeks to optimize patient outcomes through interdisciplinary teamwork [6]. Interprofessional education (IPE) promotes understanding, learning, and collaboration among different healthcare professionals to improve patient outcomes [7]. Research has demonstrated that IPE enhances team-based learning, improves patient care quality [8], shortens hospital stays, and increases medication safety [9]. In response to the growing demands of healthcare education, recent studies have explored the integration of simulation with interprofessional education through simulated interprofessional education (SIPE) models to develop both critical thinking and teamwork skills [10, 11].

Evidence suggests that SIPE benefits nursing students by improving pharmacology learning, increasing understanding of other professional roles, and strengthening interprofessional communication [12]. Similarly, SIPE has been shown to boost students' confidence in collaborative scenarios and facilitate the application of acquired knowledge, skills, and professional values to enhance patient safety and outcomes [13, 14]. While SIPE has been successfully implemented in the United States, Europe, and other Western contexts [15–17], these programs often lack a guiding theoretical framework and require more rigorous instructional design. Furthermore, single-method studies provide limited insight into educational processes, reducing their utility for refining teaching strategies.

Biggs' 3P model of learning—presage, process, and product—emphasizes critical awareness, informed decision-making, and the development of comprehensive competencies [18, 19]. Although some studies have applied the 3P framework to interprofessional simulation teaching, promoting integration among healthcare disciplines [20], quantitative-only approaches fail to explain the underlying mechanisms of learning outcomes and are insufficient for optimizing instructional design. Mixed-method research, which combines qualitative and quantitative approaches, offers complementary insights, enhances understanding of the educational process, increases student engagement, and informs more effective teaching strategies [21]. However, in China and other Asian countries, mixed-method investigations of interprofessional simulation teaching remain scarce.

To address this gap, the present study applied the 3P framework to guide interprofessional simulation teaching and employed a convergent mixed-methods approach to evaluate the impact of SIPE on nursing students' critical thinking and collaborative abilities in a "Clinical Critical Thinking" course. The study aims to provide evidence for the development of innovative teaching models in China and other Asian contexts [22].

Problem statement

This study addresses three key research questions: (1) How is the simulated interprofessional education (SIPE) model structured and implemented? (2) To what extent does the SIPE model enhance students' critical thinking, teamwork skills, and interprofessional core competencies? (3) What are students' perceptions and experiences of learning within the SIPE framework?

Materials and Methods

Design

A convergent mixed-methods approach was employed, integrating quantitative surveys with qualitative semi-structured interviews. This design was selected to leverage the complementary strengths of both approaches, providing a more comprehensive understanding of the SIPE model's impact on students' learning outcomes [21, 22]. Ethical approval for the study was obtained from the university's ethics committee. An overview of the study design and procedures is presented in **Figure 1**.

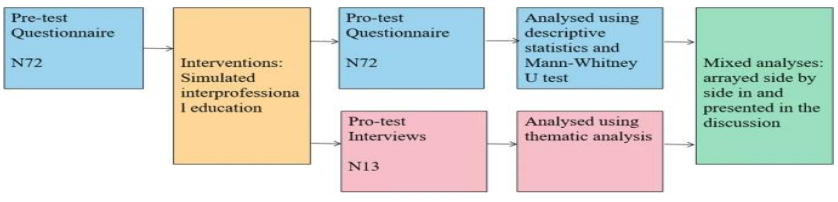


Figure 1. Study overview

Participants

A cluster sampling approach was used to recruit 60 full-time third-year nursing students from a university in China. Participants were randomly assigned to a control group (n = 36) or an experimental group (n = 24). To form interprofessional teams in the experimental group, six students majoring in clinical medicine and six students majoring in pharmacy were recruited on a voluntary basis. Inclusion criteria required that participants (1) had completed the relevant foundational medical and professional courses according to the prescribed curriculum and successfully passed course assessments, and (2) provided informed consent. Students with incomplete data were excluded from the study.

Setting and intervention

The simulated interprofessional education (SIPE) model was integrated into the "Clinical Critical Thinking Training" course, with the objective of enhancing students' clinical reasoning skills and their ability to collaborate effectively in interprofessional teams. The intervention focused on guiding students to collaboratively identify patient problems, conduct accurate assessments, make correct clinical decisions, and implement appropriate interventions to improve patient outcomes.

"Clinical Critical Thinking Training" is a core nursing course worth 2 credits, comprising 28 hours of theoretical instruction and 20 hours of laboratory-based experimental practice, totaling 48 hours. The experimental sessions were held once a week for 5 consecutive weeks, with each session lasting 4 hours. Simulation cases were collaboratively designed by faculty from nursing, clinical medicine, and pharmacy, and included scenarios involving patients from medical, surgical, and intensive care units. Both control and experimental groups utilized identical teaching materials, case scenarios, and instructors to ensure consistency.

Each simulation case required six defined roles: one doctor, one responsible nurse, one auxiliary nurse, one clinical pharmacist, one family member of the patient, and one observer, allowing all students to actively participate and assume meaningful responsibilities. A total of 12 teams were created across both groups, with six members per team. The responsible nurse served as the team leader, coordinating tasks and facilitating collaboration within the team. In the control group, nursing students performed the roles of both physicians and clinical pharmacists. In contrast, the experimental group employed the SIPE approach, assigning these roles to students from clinical medicine and pharmacy, respectively. An overview of the research groupings is presented in **Figure 2**.

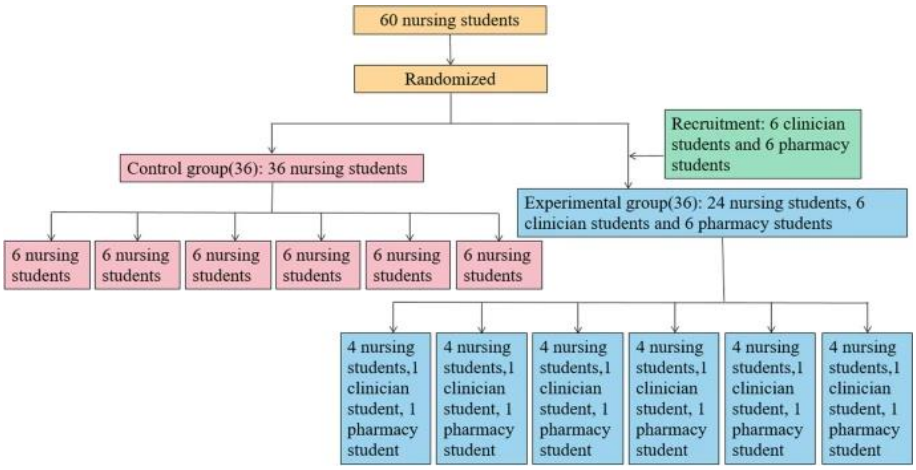


Figure 2. Research group

The study was guided by Biggs' 3P model as its theoretical framework, which conceptualizes learning in three interconnected components: learning preparation (presage), learning process (process), and learning outcomes (product). The structural framework for the SIPE program, based on this model, is illustrated in **Figure 3**.

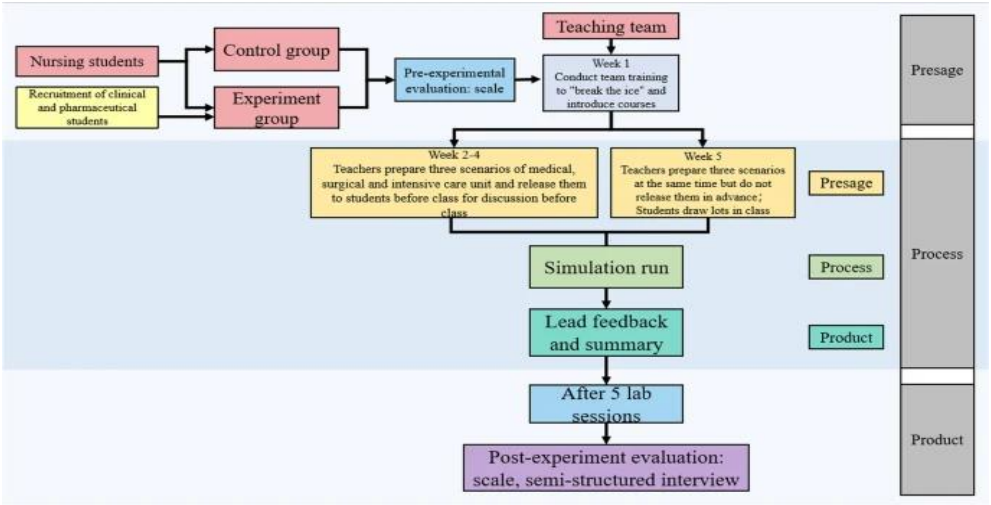


Figure 3. SIPE program design framework

Simulation procedure

Before each session, the interprofessional teaching team developed simulation cases and situational challenges, while students reviewed the relevant theoretical concepts and practical skills. Each case included three stages: admission health assessment, evaluation of the implementation of the diagnosis and treatment plan, and discharge health guidance. Each stage involved 5–10 minutes of preparation followed by 15–20 minutes of active simulation. Following recommended practices, debriefing time was allocated at a ratio of 1:2 or 1:3 relative to simulation time, lasting approximately 30–40 minutes [23].

During the simulation, team members conducted a comprehensive patient assessment from the perspective of their own professional role, shared their findings with the group, and collaboratively developed patient care plans, including examinations, treatment, and nursing interventions. All simulations were recorded. Instructors did not provide direct guidance during the sessions but could adjust the scenario dynamically as needed.

After each simulation, reflection was guided in a structured manner. Students first described their experiences and emotions to facilitate self-expression and peer discussion. They then reviewed key segments of the simulation via video, responding to questions such as, "What occurred in this scenario?", "How did you feel during the simulation?", and "What would you do differently in a future scenario?" Finally, students summarized key learning points, answered knowledge-related questions, and received instructor feedback. Evaluations focused on both individual and team performance, including clinical reasoning, teamwork, communication, and nursing-specific cognitive and behavioral skills. Instructors highlighted strengths, identified areas needing improvement, and offered recommendations for further development.

Data collection – questionnaire

Critical thinking was measured using the Chinese version of the California Critical Thinking Disposition Inventory (CCTDI), developed by Facione *et al.* [24]. The inventory assesses seven dimensions: truth-seeking, open-mindedness, systematicity, self-confidence, inquisitiveness, maturity, and analyticity. It consists of 70 items rated on a 6-point Likert scale from 1 (strongly agree) to 6 (strongly disagree), with total scores ranging from 70 to 420. Individual subscale scores of 40 or above indicate a positive disposition toward that domain, while a total score of 280 or higher reflects a generally strong critical thinking tendency [25].

Interprofessional collaboration was evaluated using the Assessment of Interprofessional Team Collaboration in Student Learning Scale (AITCS-II Student), developed by Orchard *et al.* [26] as an update of the original AITCS. This 5-point scale ranges from 1 (never) to 5 (always), with total scores between 17 and 85. A mean score of 4 or higher indicates proficient interprofessional teamwork. All participants in both experimental and control groups completed the CCTDI and AITCS-II before and after the intervention to assess changes in critical thinking and collaborative abilities [27].

Semi-structured interviews

The Interprofessional Education Collaborative identifies five key interprofessional competencies—roles and responsibilities, ethical practice, conflict management, teamwork and collaboration, and communication—which should inform the design of interprofessional learning activities [28]. To evaluate the impact of the intervention on these competencies, an interview guide was developed based on a review of the literature and clarification of the study's research questions. The guide was pre-tested and refined with input from a nursing professor and a medical anthropology professor. The finalized interview questions included: (1) How do you perceive the roles and responsibilities within your team? (2) To what extent were you able to fulfill the expectations of your professional role? (3) Did you encounter conflicts while working toward team goals, and how were they resolved? (4) Reflect on your experience with the course, including gains, challenges in interprofessional case design, and suggestions for improvement.

Participants for the interviews were purposefully selected from both the control and experimental groups to capture a range of perspectives. All interviews were conducted in a quiet, private room, and the interviewer had no prior relationship with the students nor involvement in the course design or delivery. The purpose of the interviews was explained to participants, and confidentiality was assured. With consent, the interviews were audio-recorded. The interviewer refrained from providing comments or interruptions but observed and noted non-verbal cues. At the end of each session, participants were invited to add clarifications or additional comments. Interviews were transcribed verbatim, and data collection continued until thematic saturation was reached, defined as the point at which no new information emerged.

Data analysis

Quantitative data were analyzed using SPSS 26.0 (IBM, Armonk, NY, USA). Descriptive statistics were calculated, and the Mann–Whitney U test was applied to compare differences between groups, with significance set at $\alpha = 0.05$. Qualitative interview data were analyzed thematically. Two researchers independently reviewed transcripts multiple times, identified meaningful statements, compared similarities and differences, and extracted recurring concepts to develop themes. These themes were then validated with participants and refined through

discussion among the research team. In the mixed-methods analysis, quantitative and qualitative findings were integrated and interpreted together, following Creswell's approach [29, 30].

Results – CCTDI and AITCS-II

The pre- and post-intervention scores for critical thinking and interprofessional collaboration are presented in **Table 1**. There were no significant differences between the control and experimental groups at baseline. Both groups demonstrated improvements in critical thinking and interprofessional collaboration following the simulation. However, the experimental group exhibited significantly greater gains than the control group ($p < 0.05$), indicating that participation in the SIPE program had a stronger effect on these outcomes.

Table 1. AITCS-II and CCTDI at baseline and post-intervention

	CCTDI		Z	*P*	AITCS-II Student		Z	*P*
	Control	Experimental			Control	Experimental		
Pre	237.06 ± 33.44	237.00 ± 28.34	-0.44	0.663	3.60 ± 0.39	3.76 ± 0.36	-1.86	0.063
Post	245.11 ± 30.56	284.08 ± 15.55	-5.81	< 0.01	3.64 ± 0.42	4.03 ± 0.34	-3.58	< 0.01

Abbreviations: AITCS-II Assessment of Interprofessional Team Collaboration Scale-version 2, *CCTDI* California Critical Thinking Disposition Inventory, *Pre* Pre-experiment, *Post* Post-experiment, *Z* Mann–Whitney U test values

CCTDI Post-intervention results

Post-intervention scores for the critical thinking subscales are summarized in **Table 2**. Overall, students in the experimental group demonstrated higher levels of critical thinking compared with the control group, and these differences were statistically significant ($p < 0.05$). The only exception was the systematicity subscale, where no significant difference was observed between the two groups ($p > 0.05$).

Table 2. Post-Intervention CCTDI Scores

	Control group	Experimental group	Z	*P*
	Mean ± SD	Mean ± SD		
CCTDI (Total)	245.11 ± 30.56	284.08 ± 15.55	-5.81	< 0.01
Truth-seeking	35.53 ± 7.18	39.83 ± 3.67	-2.50	0.012
Open-mindedness	37.92 ± 6.02	42.47 ± 2.72	-3.86	< 0.01
Systematicity	39.50 ± 7.13	41.86 ± 5.19	-1.41	0.158
Self-confidence	30.03 ± 4.61	38.14 ± 4.26	-6.12	< 0.01
Inquisitiveness	32.06 ± 5.34	38.03 ± 4.23	-4.70	< 0.01
Maturity	39.33 ± 7.75	44.31 ± 3.58	-2.77	0.006
Analyticity	31.75 ± 5.40	38.44 ± 3.99	-4.96	< 0.01

Abbreviations: CCTDI California Critical Thinking Disposition Inventory, *Z* Mann–Whitney U test values

Semi-structured interview findings

Data saturation was reached after 13 interviews, at which point data collection concluded. Interviews ranged from 37 to 45 minutes, with an average duration of 41 minutes. The participants included 13 nursing students, seven from the experimental group and six from the control group. Analysis of the interview transcripts resulted in three main themes and two recommendations.

Theme 1: Clarification of role through interprofessional collaboration

Students in interprofessional teams reported that clearly defined roles helped them better understand their responsibilities and adhere to professional practice standards. One student commented, "I feel that the professional competencies required for each role have been met" (E1), while another noted, "I can find my position and make a difference" (E2). In contrast, students working only within their own discipline expressed role ambiguity, stating, "Although I am playing Doctor, sometimes I still work as a nurse" (C1) and "I can't give professional advice" (C2).

Theme 2: Enhancement of team effectiveness

Students highlighted that interprofessional collaboration improved team performance. Participants in mixed-discipline teams remarked, "We work well together" (E1), "We can address challenges quickly" (E3), and "Everyone is very professional, and the advice given is convincing" (E5). Conversely, students in single-discipline teams reported challenges in coordination: "Our cooperation was not smooth, and the simulation case was not running smoothly" (C3) and "Sometimes we couldn't convince each other, so I chose to compromise" (C6).

Theme 3: Enrichment of learning experience

Students in interprofessional groups provided more positive feedback regarding the novelty and engagement of the course. Comments included, "It is more interesting to cooperate with students from other majors in the

classroom" (E7), "I feel that this format is very novel, and I will try my best to perform well" (E5), and "I hope other courses can also adopt interprofessional teaching methods in the future" (E4). By comparison, students in single-discipline teams reported lower engagement, stating, "I feel powerless when I play the role of a doctor" (C4) and "I hope to experience interprofessional education methods" (C5).

Recommendation 1: Extend laboratory class duration

Students suggested increasing class hours and the number of simulation sessions to enhance learning. Representative comments included, "Five experimental classes feel a bit short" (E1), "If time permits, I hope each scenario can be simulated twice" (E3), and "Because the first session was an introduction, we only had four actual practice sessions, which felt insufficient; more sessions would be helpful" (C3).

Recommendation 2: Expand simulation scenarios to include emergency and community settings

Students emphasized the need for more diverse scenarios to strengthen critical thinking and teamwork skills. Suggestions included incorporating emergency departments and community hospitals: "The emergency department plays a key role and should be included" (C2), "Emergency care requires strong independent judgment and problem-solving skills, so this scenario should be added" (E4), "Community healthcare is developing rapidly, and training in this context is crucial" (E7), and "I plan to work in a community hospital and would like exercises in this setting" (E5).

Results and Discussion

Integrating SIPE into the "Clinical Critical Thinking" curriculum significantly enhanced students' clinical reasoning, interprofessional collaboration skills, and core competencies across healthcare disciplines. These findings suggest that incorporating interprofessional simulation into curricula could inform the design of other courses in the future.

Critical thinking is widely recognized as a key indicator for evaluating the quality of nursing education at both undergraduate and advanced levels [31]. While previous studies, such as Smith *et al.* [32], reported that a majority of students perceived interprofessional education as improving clinical thinking, objective measurement of critical thinking was often lacking. In this study, quantitative results revealed that, with the exception of the systematicity subscale, the total and subscale scores for critical thinking in the experimental group were significantly higher than in the control group ($p < 0.01$), aligning with the findings of Xie *et al.* [33]. These results demonstrate that simulated interprofessional education can effectively strengthen clinical reasoning in nursing students. Similarly, Aein *et al.* [34] reported that SIPE interventions enhance analytical and deductive reasoning. The simulation-based interprofessional approach provides a safe, controlled clinical environment for repeated practice, testing hypotheses, and refining judgment skills [4, 8]. By engaging students with cases from medical, surgical, and intensive care units, the intervention improved analytical ability and self-confidence. The lack of significant improvement in systematicity may be attributable to limited intervention duration, a limitation reflected in students' qualitative feedback requesting longer class hours. Future studies could extend instructional time to better assess its effect on this dimension.

Quantitative findings also showed that the experimental group achieved higher scores in interprofessional collaboration than the control group. This suggests that interprofessional teams promoted effective teamwork, active communication, and coordination toward shared goals, consistent with prior research [35, 36]. Qualitative findings corroborated these results, explaining the mechanisms by which SIPE improved teamwork. In clinical practice, integrating medical and nursing staff through joint planning, decision-making, goal-setting, and shared responsibility requires mutual trust and respect [37]. Poor communication and collaboration between nurses and physicians can compromise patient safety and care quality, potentially leading to adverse outcomes [38].

In this study, establishing interprofessional learning teams mitigated issues associated with low self-efficacy and limited role experience in traditional single-profession simulations. The experimental team structure enhanced student engagement, promoted active participation, and facilitated achievement of team objectives, fostering trust and respect between professions. Conversely, the control group experienced role ambiguity, which may have led to conflict, reduced team effectiveness, and burnout. When students were assigned roles outside their professional training, they struggled to provide role-consistent input, resulting in compromise strategies that slowed decision-making. The interprofessional composition of the experimental group alleviated these challenges, improving both efficiency and role clarity.

Effective communication is central to interprofessional education and is critical for teamwork. Efficient information exchange allows teams to identify patient needs accurately, make timely clinical decisions, and achieve care goals more effectively [39, 40]. The experimental group demonstrated superior communication and task coordination, reflecting a model closer to integrated medical and nursing practice. In contrast, the control group required longer time to achieve similar outcomes due to less effective collaboration. High-functioning teams

not only accomplish tasks more efficiently but also increase members' confidence, motivation, and problem-solving abilities, reinforcing the value of SIPE in promoting both clinical and interpersonal competencies.

During the study, students suggested incorporating emergency department scenarios into the simulations due to the high demands these settings place on critical thinking and teamwork. However, given limited class hours, it was challenging for students to meet the necessary competencies, so a separate emergency department scenario was not formally included. To address this, during the fifth week of the course, the instructor conducted an unannounced simulation by randomly selecting a case to approximate an emergency situation. The community hospital scenario suggested by students was not included in the initial design. Future curriculum revisions plan to increase the number of experimental sessions, enabling the inclusion of additional cases and scenarios for more comprehensive simulation experiences.

This study contributes to nursing education and simulation research in several ways. First, in terms of study design, prior research often recruited control and experimental groups from different academic years [41], potentially introducing confounding effects from varying educational backgrounds. In contrast, this study drew participants from the same academic year, minimizing such biases. Second, unlike previous studies where teaching teams were composed entirely of instructors from the same discipline [42], this study utilized a cross-major teaching team, enhancing the realism and clinical relevance of the simulation cases. Third, while most prior studies relied solely on quantitative measures [43], this study employed a convergent mixed-methods approach, integrating both quantitative and qualitative analyses to provide a richer and more comprehensive understanding of the intervention's effects.

Several limitations should be acknowledged. The sample size was relatively small due to the limited enrollment of participating schools, which may affect the generalizability of the results. Future studies will include larger samples and multiple institutions to enhance reliability and applicability. Additionally, interprofessional participation was limited; only students from clinical medicine and pharmacy were recruited due to early-stage recruitment constraints. Expanding recruitment to include other disciplines such as psychology, rehabilitation, and nutrition in future studies will allow for deeper interprofessional collaboration.

Conclusion

Guided by Biggs' 3P model, this study designed and implemented a simulated interprofessional education course, "Clinical Critical Thinking," in a Chinese nursing education context. Findings indicate that the SIPE model effectively enhances students' critical thinking, interprofessional collaboration skills, and core competencies across healthcare professions. These results support the potential of SIPE as a framework for the design of similar courses in the future, providing a foundation for more integrated and practice-oriented interprofessional education.

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