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Effect of integrated case-based and problem-based learning on clinical thinking skills of assistant general practitioner trainees: a randomized controlled trial

Dingyuan Jiang[1,2], Danpei Huang[3], Hua Wan[4], Wuliang Fu[5], Weidong Shi[6], Jin Li[7], Huan Zou[8], Niannan Hou[9], Qing Li[5] and Nani Li[2,3*]

Abstract

Background Case-Based Learning (CBL) and Problem-Based Learning (PBL) are popular methods in medical education. However, we do not fully understand how they affect the clinical thinking skills of Assistant General Practitioner (AGP) trainees. This randomised controlled trial aimed to assess the effectiveness of combining CBL and PBL and compare their impact on the clinical thinking skills of AGP trainees with that of traditional lecture-based learning (LBL).

Methods This randomised controlled trial involved 70 second-year AGP trainees who were randomly assigned to either the CBL-PBL group or the LBL group using a simple randomisation method. The CBL-PBL group engaged in a curriculum that integrated case-based and problem-based learning, whereas the LBL group followed a traditional lecture-based format, as described in the syllabus. To evaluate clinical thinking skills, the participants were assessed using the Clinical Thinking Skills Evaluation Scale (CTSES) and an assistant general practitioner's professional knowledge test. In addition, this study analysed various factors that influence clinical thinking skills.

Results Compared with the LBL group, the CBL-PBL group showed significantly improved performance in all domains assessed by the CTSES in post-course tests ($p < 0.001$). Specifically, the mean scores for critical, systematic, and evidence-based thinking showed notable improvement in the CBL-PBL group. Additionally, the scores on the professional knowledge test reflected a substantial increase in this group. Furthermore, multiple linear regression analysis showed that both CBL-PBL curriculum performance scores and number of weekly article readings significantly influenced the development of clinical thinking skills.

Conclusion The CBL-PBL teaching method positively influenced the clinical thinking skills of assistant general practitioner trainees, with a positive correlation between these skills and course performance in the CBL-PBL curriculum.

Trial registration Not applicable.

*Correspondence:
Nani Li
lnn4098@163.com

Full list of author information is available at the end of the article

Keywords Clinical thinking, Case-based learning, Problem-based learning, Assistant general practitioner training

Introduction

Clinical thinking, a complex process, integrates medical knowledge, clinical experience, and patient-specific information for diagnosing diseases, establishing diagnoses, and developing treatment plans [1]. This process goes beyond the collection and analysis of medical histories, physical examinations, and symptoms; it also involves making medical decisions [2]. In the field of medical education, the cultivation of clinical thinking skills is of paramount importance, as it directly impacts the performance of medical students and physicians in clinical practice and the quality of medical decision-making [3]. Clinical thinking skills include critical thinking, systems thinking, evidence-based thinking, and other important aspects that can be enhanced through educational training and the accumulation of practical experience [4, 5].

The Assistant General Practitioner (AGP) training program is a two-year standardized training program (i.e., the "3 + 2" model) designed for medical practitioners with a three-year tertiary qualification [6–8]. This program necessitates the successful completion of three years of specialized clinical medicine education, which is subsequently followed by a two-year standardized training regimen for aspiring assistant general practitioners [7]. This programme has been designed to complement and reinforce the training of general practitioners, enhance the capacity of primary healthcare services rapidly and efficiently, and meet the needs of China's healthcare reform and development [9]. The clinical thinking skills of AGP trainees are directly related to the quality and efficiency of their subsequent medical services in primary care. Exploring effective teaching methods for AGP training and improving the clinical thinking skills of AGP trainees are crucial for enhancing the level of primary healthcare services.

Traditional lecture-based learning (LBL) remains a mainstream teaching method in the field of medical education and training [10, 11]. This approach has its unique and efficient value in imparting basic medical knowledge and concepts, especially suitable for knowledge dissemination and concept explanation to large groups [12]. However, this approach has been found to be less effective than alternative methods in fostering clinical thinking skills that are essential for students [13–15]. Case-Based Learning (CBL) is a teaching method that uses specific case analyses to encourage trainees to learn relevant knowledge and develop clinical thinking and problem-solving skills [16–18]. CBL pedagogy may be excessively dependent on the quality and relevance of the cases, potentially restricting students' exposure to diverse knowledge points and necessitating a high level of expertise in case design and facilitation from the instructor [19]. Problem-Based Learning (PBL) is a pedagogical approach that emphasizes problem-centered learning, encouraging students to learn independently around a specific problem [20]. This facilitates their in-depth understanding and mastery of knowledge through teamwork and discussions [21, 22]. Nevertheless, the PBL method may pose challenges for novice learners or students with limited self-study skills. The integration of CBL and PBL optimises the benefits of the two pedagogical approaches. CBL encourages trainees to engage in learning through case studies whereas PBL fosters a problem-oriented approach that enhances critical thinking.

However, there is still a significant knowledge gap in existing research on how the integration of CBL and PBL affects the development of comprehensive clinical thinking skills in AGP trainees, and these integrated methods are less effective than traditional LBL methods in cultivating critical, systematic, and evidence-based comparative effects in thinking have not been fully explored. This study aimed to explore whether the integrated CBL-PBL teaching method is more effective than the traditional LBL method in improving clinical thinking skills of AGP trainees.

Methods

Design and participants

This study was designed as a prospective, parallel-group, randomised controlled trial (RCT) with a 1:1 allocation ratio. This study was formally reviewed and approved by the Ethics Committee of Zhuzhou 331 Hospital (approval number: ZZS331YYLL-202102-JX1-J1). Participants were recruited from the Assistant General Practitioner (AGP) training program at Zhuzhou 331 Hospital between 1 June 2021 and 1 September 2023. The study timeline encompassed the entire process, from participant enrolment to the completion of data collection. Participants were included if they (1) demonstrated good communication and comprehension skills, (2) fully engaged in the training program without any absences or instances of truancy, and (3) fulfilled all prescribed learning tasks. The exclusion criteria were as follows: (1) lack of assistant physician practice qualification, (2) inability to complete the training curriculum, (3) failure to complete the pre-course and post-course test assessments, and (4) incomplete or deficient responses to the study questionnaires.

Interventions

The CBL-PBL curriculum is structured into seven modules designed to enhance the participants' clinical reasoning and problem-solving skills. (Supplementary Material 1) The initial module comprises three one-hour lectures that cover the fundamental concepts of CBL-PBL pedagogy, mind mapping techniques, and methods for literature retrieval. This foundational segment equips the participants with a robust theoretical framework and prepares them for subsequent practical exercises. The subsequent six modules consisted of intensive three-hour CBL-PBL sessions. Prior to each session, the instructional team provided trainees with essential materials, including general diagnostic and therapeutic guidelines, five academic papers pertinent to the session's theme, and a 30-minute clinical procedure video to augment their practical understanding. At the beginning of each session, the instructor offered a brief introduction to the topic and outlined the objectives of the session. The participants then engaged in a simulated patient encounter to identify and articulate key clinical issues, based on the presented case study. In-depth group discussions followed, progressively deepening our understanding of the case. Instructors should encourage trainees to pose questions and evaluate their responses. Subsequently, a representative from each group summarises the key points, shares the group's findings, and highlights unresolved issues. The session concludes with a comprehensive review by the instructor, addressing the challenges encountered during discussions with expert insights and guidance.

By contrast, traditional lecture-based learning (LBL) follows a predetermined curriculum and training plan. Students are expected to review lectures or relevant texts in accordance with the syllabus or training schedule in order to better comprehend the upcoming material. (Supplementary Material 2) During lectures, the instructor primarily imparts knowledge through verbal presentations, often employing slides and other visual aids to enhance educational experience. Instructor-led didactic sessions were central to this teaching modality [23, 24].

Outcomes

Clinical thinking skills evaluation scale (CTSES) The CTSES served as the primary assessment tool in this study and was specifically designed to quantitatively evaluate the clinical thinking skills of trainees [2]. It encompasses three fundamental dimensions–critical thinking, systems thinking, and evidence-based thinking–with a total of 24 rating items, six of which pertain to critical thinking skills, 11 to systems thinking skills, and seven to evidence-based thinking skills [2]. Participants rated the items on a five-point Likert scale with a total possible score of 120, which was converted to a percentage for statistical analysis. (Supplementary Material 3) The scale demonstrated a Cronbach's alpha of 0.962 and a test-retest reliability of 0.861.

Assistant general practitioner knowledge assessment This study was designed with the understanding that clinical knowledge is fundamental to clinical reasoning skills, resulting in the creation of two examination papers of equal difficulty. (Supplementary Material 4 and 5) The content of the examination papers strictly adheres to the curriculum for assistant general practitioners and utilizes Bloom's Taxonomy of Educational Objectives [25]. Drawing inspiration from the study by Yan et al. [23], which employed analogous assessment instruments in a related context, each examination papercompriseds 10 case, and each casewass accompanied byfive5 related questions, with a total score of 100 points. The assessments were subjected to preliminary difficulty evaluations by seasoned educational experts, and underwent several adjustments following small-scale pilot testing to ensure scientific rigor and validity.

The othor outcomes included course performance ranking, the number of weekly article readings, and weekly self-study time. Performance score ranking was based on course performance ratings using a Course Performance Rating Scale. This scale, informed by prior research [26], comprehensively addresses four key competency domains: communication skills, teamwork and collaboration, comprehension and reasoning, and knowledge- and information-gathering. Each domain consists of five rating scales ranging from one to five. These scales were accompanied by clear definitions for reference purposes. (Supplementary Material 6).

Data collection

On the day before the start of the first semester of the second academic year, all participants were required to complete the pre-course test and CTSES questionnaires separately. On the last day of the first semester of the second academic year, all participants were once again asked to complete the same difficulty post-course test and questionnaire as the CTSES separately. Additionally, the questionnaire included items on the number of weekly article readings and the weekly self-study times of the participants. After each module's course ends, teachers grade each student's course performance according to course performance grading standards. Once all courses were completed, the scores given by all the teachers for each student were collected and averaged for ranking purposes.

Sample size calculation

In this study, we performed a sample size estimation to detect differences in the impact of CBL-PBL teaching

methods on the clinical thinking skills of assistant general practitioners in training compared to the LBL group. A preliminary experiment involved 20 participants randomly assigned to either the CBL-PBL or the LBL group, with 10 participants in each group. The CBL-PBL group had a mean score of 70.53 (SD = 10.02), whereas the LBL group had a mean score of 63.45 (SD = 8.61). Using G*Power software (Version 3.1.9.7), we conducted a sample size calculation with a significance level (α) of 0.05 for a two-tailed test and aimed for a statistical power of 1-β = 0.80. The initial calculation suggested that 29 participants per group were required to detect significant differences. Anticipating a 10% dropout rate, we adjusted the sample size to 32 participants per group, for a total of 64. To ensure the robustness of the study, we included 35 participants per group, resulting in a final sample size of 70 participants.

Randomization

In this study, we employed a simple randomization method in which independent randomization staff, uninvolved in recruitment or intervention, sequentially numbered participants based on their registration numbers and assigned new identifiers ranging from 1 to N [23, 24]. Participants with odd identifiers were allocated to the CBL-PBL group, whereas those with even identifiers were assigned to the LBL group. This method did not involve block randomisation or stratified randomisation, nor were there any restrictions such as block sizes. The random allocation sequence was generated by independent randomisation of staff members who did not participate in subsequent recruitment or intervention processes. Recruitment of participants was conducted by the research team and participant allocation was automatically completed based on the aforementioned numbering system. The study adopted a non-triple-blind design, with only the randomisation staff being unaware of the group allocations, while the participants and intervention providers were not blinded. Students were aware of their group assignments and educators were cognizant of the instructional methods they were delivering.

Statistical methods

Fisher's exact test was used to evaluate the distribution of sex and place of birth between patient groups. For continuous variable comparisons between groups, the independent samples t-test was used if the data showed a normal distribution and homogeneous variance; otherwise, the Mann-Whitney U-test was used. For within-group paired sample comparisons, the paired t-test was used if the data exhibited normal distribution and homogeneous variance. Welch's t-test was used when variance was not homogeneous. The Wilcoxon signed-rank test was applied in the absence of normal distribution. One-way analysis of variance (ANOVA) was used for clinical thinking score comparisons among three or more groups. Multiple linear regression analyses were conducted to identify the influencing factors. Statistical significance was set at $p < 0.05$ (and two-tailed) were used to determine statistical significance. All analyses were performed using the IBM SPSS software (version 27.0; IBM Corporation, Armonk, NY, USA).

Result

In this study, a total of 72 participants were identified as eligible during the recruitment phase. Two participants were excluded based on the predefined exclusion criteria prior to randomisation. Consequently, 70 participants were randomly allocated to either the CBL-PBL or the LBL group, where they received the designated instructional interventions. Of these, 68 participants successfully completed all assessments and surveys, and were subsequently included in the analysis of the primary outcome. It is noteworthy that two participants in the LBL group were unable to complete the assessments because of medical leave and were therefore not included in the primary outcome analysis. The recruitment period spanned from 1 June 2021 to 1 September 2023. The study proceeded to completion as scheduled, without any interruptions attributable to pedagogical concerns or other issues, and it fulfilled the targeted sample size and educational objectives. A participant flow diagram is shown in Fig. 1.

Baseline characteristics

The gender distribution of the participants was 19 males and 51 females. Geographically, participants were distributed as follows: 21 from the countryside and 48 from the city. Statistical analysis revealed no significant differences between the CBL-PBL and LBL groups in terms of gender, birthplace and age. (Table 1).

The scoring results of the clinical thinking skills assessment scale

Table 2 indicates that the CBL-PBL group exhibited significantly higher post-course test performance in all assessed domains: critical, systematic, and evidence-based thinking. The score for critical thinking skills in the CBL-PBL group increased from 8.333 in the pre-course test to 18.333 in the post-course test, while the LBL group's score increased from 8.359 to 13.660, indicating significantly greater improvement in the CBL-PBL group. Total clinical thinking skills in the CBL-PBL group showed significant improvement, with scores increasing from 30.833 to 72.5. In comparison, the LBL group showed modest improvement, with scores increasing from 33.232 to 54.697. These findings indicate that the CBL-PBL teaching method significantly enhanced the

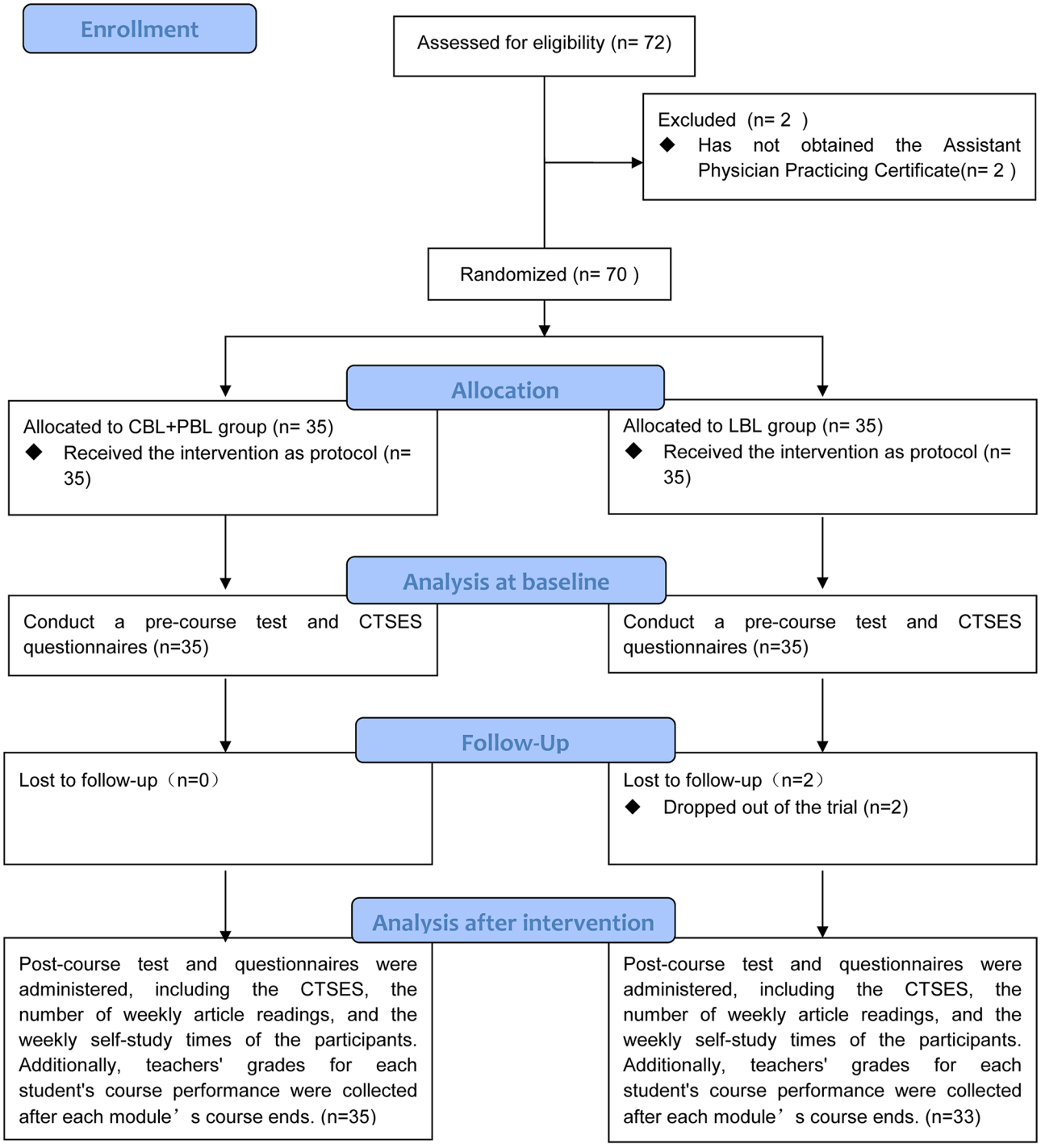

Fig. 1 Flow diagram

clinical thinking skills of assistant general practitioner trainees.

Assistant general practitioner professional knowledge test results

We assessed the clinical thinking skills of trainees using Professional Knowledge Test scores. Table 3 presents the mean pre-course test scores, which were 62.114 and 62.515 for the CBL-PBL and LBL groups, respectively. No significant difference in pre-course tests was observed between the groups ($p = 0.784 > 0.05$), indicating equivalence at baseline. In the post-course test, the mean score of the CBL-PBL group increased to 86.371, which was significantly higher than that of the pre-course

Table 1 The baseline characteristics of all the participants

Item	CBL-PBL group ($n=35$)	LBL group ($n=35$)	*P* value
Gender			0.788
Male	9	10	
Female	26	25	
Birthplace			0.797
City	23	25	
Countryside	12	10	
Age[M(P25,P75)]	22(22,23)	22(22,23)	0.787

Note: In the final analysis, two participants from the LBL group who did not complete the test and questionnaire were excluded, resulting in an analysis of 33 participants in the LBL group and 35 in the CBL-PBL group

Table 2 Clinical thinking scale scores of two groups

Item	Pre-course test			Post-course test			P^c	P^d
	CBL-PBL	LBL	p^a	CBL-PBL	LBL	p^b		
Critical Thinking Skills	8.333*	8.359 ± 1.405	0.663	18.333*	13.660 ± 1.815	0.000	0.000	0.000
Systematic Thinking Skills	14.167*	15.227 ± 4.079	0.882	32.500 ± 5.612	25.076 ± 4.063	0.000	0.000	0.000
Evidence-based Thinking Skills	9.167 ± 2.152	9.646 ± 2.500	0.454	20.000*	15.960 ± 2.685	0.000	0.000	0.000
Total Clinical Thinking Skills	30.833*	33.232 ± 7.514	0.631	72.500 ± 10.353	54.697 ± 7.75	0.000	0.000	0.000

Note: (a) The Mann-Whitney U test was used to compare pre-course tests of the CBL-PBL and LBL groups for critical thinking skills, systematic thinking skills, and total clinical thinking skills, and a t-test was used to compare pre-course tests on evidence-based thinking skills between the CBL-PBL and LBL groups. (b) The Mann-Whitney U test was used to compare post-course tests for critical thinking and evidence-based thinking between the CBL-PBL and LBL groups, and Welch's t-test was used to compare post-course tests for systematic thinking and total clinical thinking skills between the CBL-PBL and LBL groups. (c) The paired-sample Wilcoxon signed-rank test was used to compare the post-course test with the pre-course tests within the CBL-PBL group. (d) A paired-sample t-test was used to compare the post-course test with the pre-course tests within the LBL group. (e) The median is marked with an asterisk (*)

Table 3 Clinical thinking skills in professional knowledge test scores for the two groups

Groups	Pre-course test	Post-course test	Statistics	p^b
CBL-PBL group	62.114 ± 5.588	86.371 ± 6.89	t = -17.043	0.000
LBL group	62.515 ± 6.399	71.727 ± 5.597	t = -6.851	0.000
Statistics	t = -0.276	t = 9.585		
p^a	0.784	0.000		

Note: (a) An independent sample t-test was used to compare pre-course test results between the CBL-PBL and LBL groups. (b) A paired sample t-test was used to compare the post-course test with the pre-course tests in the CBL-PBL and LBL groups

test (t = -17.043, $p<0.001$). Similarly, the LBL group demonstrated an improvement in their post-course tests, with a mean of 71.727, which was also statistically significant (t = -6.851, $p<0.001$). The post-course test difference between the two groups was statistically significant (t = 9.585, $p<0.001$), signifying a markedly greater enhancement in the CBL-PBL group than that in the LBL group. In summary, the CBL-PBL instructional approach bolsters trainees' clinical thinking skills in assistant general practitioner programs.

Factors influencing clinical thinking skills in the CBL-PBL group

This study analysed the demographic characteristics, the number of weekly articles readings, weekly self-study time, and CBL-PBL course performance rankings to investigate the factors affecting the clinical thinking skills of assistant general practitioner trainees in the CBL-PBL group. The results are presented in Table 4. Univariate analysis identified factors influencing clinical thinking skills among the CBL-PBL group trainees. The analysis revealed that gender (t = -0.287, $p=0.776$) and birthplace (t = 0.438, $p=0.664$) did not significantly affect clinical thinking skills. Notably, the CBL-PBL performance score ranking and number of weekly article readings significantly influenced trainees' clinical thinking skills. Participants in the top 30% of the CBL-PBL performance score rankings had the highest mean score (81.833 ± 2.034), whereas those with fewer than two articles per week had the lowest mean score (59.936 ± 7.488). Furthermore, Weekly self-study time significantly influenced clinical thinking skills (F = 4.854, $p=0.014$), with participants studying more than four hours per week exhibiting higher average scores (77.5 ± 8.531).

Factors influencing clinical thinking skills of trainees in the CBL-PBL group showed a positive correlation with clinical thinking skills

Clinical thinking skills in the CBL-PBL group positively correlated with several factors. We performed a multiple linear regression analysis to determine the factors influencing clinical thinking skills among assistant general

Table 4 Analysis of influential factors on the clinical thinking skills in the CBL-PBL group

Item	*N*	Scores (mean ± SD)	t or F value	*p*
Gender			t = -0.287	0.776
Male	9	69.444 ± 12.105		
Female	26	70.609 ± 9.926		
Birthplace			t = 0.438	0.664
City	23	70.87 ± 11.048		
Countryside	12	69.236 ± 9.235		
Performance scores ranking			F = 78.937	0.000
Top 30%	10	81.833 ± 2.034		
Between top 30% and last 30%	16	70.833 ± 4.907		
Last 30%	9	56.574 ± 5.195		
The number of weekly articles readings			F = 41.316	0.000
More than 4 articles per week	9	81.574 ± 3.158		
2–4 articles per week	13	72.885 ± 4.697		
Less than 2 article per week	13	59.936 ± 7.488		
Weekly self-study time			F = 4.854	0.014
More than 4 h per week	6	77.5 ± 8.531		
2–4 h per week	19	71.754 ± 8.16		
Less than 2 h per week	10	63.25 ± 11.709		

Table 5 Multiple linear regression analysis of influencing factors on clinical thinking skills of medical students for the CBL-PBL group

Factors	B	SE	Beta	t
Constant term	43.948	2.452		17.920
Performance scores ranking	9.366	1.862	0.676	5.030
The number of weekly articles readings	3.278	1.741	0.252	1.882
Weekly self-study time	0.627	1.238	0.41	0.506

Note: B, non-standard regression coefficient; SE, Standard error; Beta, standardised regression coefficient; F = 56.671, adjusted $R^2 = 0.831$, $p < 0.001$

practitioner trainees in the CBL-PBL group.(Table 5) The unstandardised regression coefficient (B) for CBL-PBL performance score ranking was 9.366 (SE = 1.862), beta = 0.676, and t = 5.030. The *p*-value was 0.000, and the 95% confidence interval ranged from 5.568 to 13.163, indicating that the CBL-PBL performance score ranking significantly influenced clinical thinking skills. The B-value for the number of weekly article readings was 3.278, with a standard error (SE) of 1.741, standardised regression coefficient (Beta) of 0.252, t-value of 1.882, and a *p*-value of 0.069. The trend was positive, but did not reach statistical significance, with a 95% confidence interval of -2.274 to 6.829. The B-value for CBL-PBL weekly self-study time was 0.627, with a standard error (SE) of 1.238, a standardised regression coefficient (Beta) of 0.41, a t-value of 0.506, a *p*-value of 0.616, and a 95% confidence interval of -1.898 to 3.152. These results indicate that weekly self-study time does not significantly affect clinical thinking skills.

Discussion

In the field of medical education, traditional didactic teaching methods have proven ineffective at fostering students' clinical thinking skills [12]. Previous research has highlighted the distinct advantages of PBL and CBL, both of which are typically employed independently. This study combines CBL and PBL pedagogies to integrate their strengths and complement their weaknesses. The integration of cases and problems pedagogies provides a more dynamic and engaging learning environment [23, 24, 27]. The impact of a combined CBL-PBL instructional curriculum on trainees' clinical thinking skills in assistant general practitioner training was explored by comparing it with traditional lecture-based teaching (control group).

Chen et al. [27] observed that students instructed using the CBL-PBL approach exhibited greater satisfaction and superior performance in terms of their knowledge and ability to address genuine clinical issues. Yan et al. [23]noted that the CBL-PBL self-assessment scores were superior to those of the traditional group across key areas. Zhao et al. [24] reported that the PBL-CBL group achieved significantly higher scores than did the traditional group in various areas. In contrast to the aforementioned studies that evaluated the effects of multiple indicators in depth, this study focused on assessing students' clinical thinking skills based on the CBL-PBL instructional curriculum design. In the selection and design of cases, we carefully selected cases that were closely related to the daily work of assistant general practitioners. These cases not only widely cover various fields

of medicine but also cleverly incorporate key elements of community health and preventive medicine, aiming to comprehensively strengthen the holistic and continuous concepts of general practice. In the implementation of the teaching process, we consistently adhere to the principle of "student-centered, teacher-guided." In the classroom, we focus more on in-depth discussions of cases and intensive training in clinical reasoning to spark students' intellectual sparks and have introduced a scientific evaluation mechanism that works together to effectively enhance the clinical thinking skills of assistant general practitioner trainees.

Furthermore, in contrast to previous studies that used a singular self-evaluation scale approach [23], the present study evaluated trainees' clinical thinking skills using the professional knowledge examination and clinical thinking skills scale scores. The results were first analysed based on professional knowledge examination scores at the end of the course, demonstrating that the CBL-PBL group's examination scores were significantly higher than those of the control group. This suggests that the CBL-PBL method can significantly improve the trainees' thinking skills. Second, we conducted a further analysis of the scores obtained on the Thinking Skills Evaluation Scale in the two groups; the results were similar in both cases. Before the commencement of the semester course, the CBL-PBL group demonstrated a greater level of familiarity with the course material than did the control group. There were no statistically significant differences in the pre-course professional knowledge examination and clinical thinking skills scale scores between the control and CBL-PBL groups before the semester began. This indicates that the enhancement in clinical thinking skills was not due to disparate pre-course materials, but rather to the distinctive characteristics of the two teaching methodologies. Consequently, it can be posited that the CBL-PBL teaching method may be a more efficacious approach for fostering clinical thinking skills among trainee general practitioners.

Clinical thinking skills are the cognitive skills used by medical professionals in diagnosis and treatment, including critical thinking, systems thinking, and evidence-based thinking [2]. The CBL-PBL model facilitates medical knowledge acquisition through trainees' interactions with clinical cases and problems, enabling them to reflect on and adjust their thinking patterns, thereby developing mature and comprehensive clinical thinking skills. In addition, the CBL-PBL model promotes the depth and breadth of trainees' clinical thinking [23, 24]. PBL has been recognized as an educational method that fosters critical thinking [28, 29]. This study further analysed the dimensions of the Clinical Thinking Scale. The results demonstrated that CBL-PBL pedagogy significantly enhances trainees' critical systems and evidence-based thinking. Consequently, adopting CBL-PBL pedagogy enabled trainees to comprehensively develop higher-order thinking skills, resulting in significantly improved overall literacy.

Both CBL and PBL encourage students to actively engage in the learning process by analyzing cases or problems to guide their learning rather than passively receiving knowledge [30, 31]. The CBL-PBLcourse provides skills, including communication, teamwork, comprehension, reasoning, and information literacy. In this study, student performance throughout the CBL-PBL course was assessed through instructor evaluation. Additionally, questionnaires were used to gather information on participants' literature reading frequency and the time spent on independent studies. The relationships between these variables and clinical thinking skills were also examined. Among these factors, performance ranking in the CBL-PBL course had a significantly positive influence on clinical thinking skills. This finding is consistent with those of similar studies [2].

This study had some limitations. First, the sample size was small, and the data only came from a single centre, which may have limited the general applicability and transferability of the research results. Second, as the study design did not adopt a triple-blind method, execution and measurement biases may have been introduced, thereby affecting the objectivity of the results. Additionally, due to the short period of intervention and evaluation, we were unable to fully assess the long-term effects and sustainability of the CBL-PBL teaching method. Finally, this study failed to comprehensively evaluate the multidimensional outcomes of educational interventions, and the consistency of CBL-PBL implementation may have been affected by individual differences between teachers and students, a variable that was not sufficiently controlled for in this study. Despite these limitations, our findings have implications for the extrapolative validity. The potential benefits of the CBL-PBL teaching method for enhancing clinical thinking skills may also apply to other educational environments and populations. However, to increase the generalisability of these findings, future research should consider designs with multicentre and large sample sizes and conduct long-term follow-up assessments.

Conclusion

The CBL-PBL teaching method positively influenced the clinical thinking skills of assistant general practitioner trainees, with a positive correlation between these skills and course performance in the CBL-PBL curriculum.

Abbreviations

PBL	Problem based learning
CBL	Case based learning
LBL	Lecture based learning

AGP Assistant general practitioner
CTSES Clinical thinking skills evaluation scale

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Supplementary Information

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Supplementary Material 1: The AGP Training Blueprint: A Curriculum Combining Case-Based Learning and Problem-Based Learning.

Supplementary Material 2: Standards for the Training of Assistant General Practitioners (2020 Edition).

Supplementary Material 3: Clinical Thinking Skills Evaluation Scale.

Supplementary Material 4: Pre-course test of Assistant General Practitioner Professional Knowledge.

Supplementary Material 5: Post-course test of Assistant General Practitioner Professional Knowledge.

Supplementary Material 6: Course Performance Grading Scale and Scoring Criteria.

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Author contributions

LNN and JDY performed data collection, interpretation, statistical analyses, and drafted the manuscript. HDP, WH, FWL, SWD, LJ, ZH, HNN and LQ performed data interpretation, and helped to draft the manuscript. LNN adn JDY designed this study, contributed to interpret the data and draft the manuscript. All authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was formally reviewed and approved by the Ethics Committee of Zhuzhou 331 Hospital (approval number: ZZS331YYLL-202102-JX1-J1). Before the commencement of the study, all participants were thoroughly informed of the study's objectives, procedures, potential risks, and benefits. The participants voluntarily signed informed consent forms after fully understanding their information.

Competing interests

The authors declare no competing interests.

Author details

[1]Department of Spinal Surgery, Zhuzhou 331 Hospital, Zhuzhou, China
[2]Department of Science and Education, Zhuzhou 331 Hospital, Zhuzhou, China
[3]Department of General Practice, Zhuzhou 331 Hospital, Zhuzhou, China
[4]Department of Otorhinolaryngology, Zhuzhou 331 Hospital, Zhuzhou, China
[5]Department of Emergency, Zhuzhou 331 Hospital, Zhuzhou, China
[6]Department of Cardiology, Zhuzhou 331 Hospital, Zhuzhou, China
[7]Department of Neurology, Zhuzhou 331 Hospital, Zhuzhou, China
[8]Department of General Surgery, Zhuzhou 331 Hospital, Zhuzhou, China
[9]Department of Pulmonology, Zhuzhou 331 Hospital, Zhuzhou, China

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