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Study on the Application of PBL-CBL Teaching Model in Orthopedic Clinical Probation Courses

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Abstract

Objective: To explore the role of Problem-Based Learning (PBL)+Case-Based Learning (CBL) orthopedic clinical teaching model in improving teaching quality. **Methods:** A total of 240 undergraduate students who participated in orthopedic probation from January 2023 to June 2024 were selected as the research objects and randomly divided into 4 groups, with 60 students in each group. The control group adopted the lecture-based learning (LBL) method, while PBL-CBL group used PBL+CBL teaching method, PBL group used PBL teaching method, and CBL group used CBL teaching method. After the course, teachers evaluated the four groups of students through comprehensive performance, and students evaluated the course via online questionnaires. **Results:** There were no statistically significant differences in gender and age among the four groups of students ($P > 0.05$). Compared with the control group, the exam scores (written examination and practical operation assessment) and student evaluation scores of PBL-CBL group were the highest, with statistically significant differences ($P < 0.05$). There were no significant differences in exam scores and student evaluation scores between experimental group 2 and experimental group 3 compared with experimental group 1 ($P > 0.05$). All three experimental groups were higher than the control group. **Conclusion:** The PBL+CBL teaching method can achieve satisfactory teaching results in orthopedic probation teaching.

Keywords

Problem-Based Learning, Case-Based Learning, Lecture-Based Learning

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1. Introduction

Orthopedics is a discipline with a wide scope and involvement in multiple fields, placing great emphasis on clinical practice and application. Therefore, how to transform theory into practice has become the key and difficulty in orthopedic probation teaching courses. However, the traditional lecture-based learning (LBL) teaching model, which takes teachers as the main body and teaching as the core, can no longer meet the needs of current orthopedic teaching [1]. In recent years, problem-based learning (PBL) [2]-[4] and case-based learning (CBL) [5]-[7] have received increasing attention in domestic and foreign education. Nevertheless, both single PBL or CBL teaching models have shortcomings: the pure PBL curriculum model cannot systematically connect knowledge points, leading to difficulties in constructing a knowledge system for students [8]; the pure CBL teaching model makes the course lack interaction and fail to consolidate knowledge points in a timely manner. Improper operation may seriously affect teaching effectiveness [9]. To make up for their respective defects, scholars have combined PBL with CBL to make the teaching plan more reasonable and efficient [10] [11]. However, the teaching model combining PBL and CBL is still rare in orthopedic probation teaching. In order to further improve teaching efficiency, we designed the orthopedic probation teaching course as a PBL-CBL teaching model to form a reasonable and effective teaching plan. This study conducted teaching with different methods for 5-year undergraduate students majoring in clinical medicine during their orthopedic probation in our hospital, and summarized the teaching outcomes of four teaching models: LBL, PBL, CBL, and PBL-CBL. The report is as follows.

2. Materials and Methods

2.1. Students

A total of 240 five-year undergraduate students majoring in clinical medicine who underwent orthopedic probation at the Second Affiliated Hospital of Guangxi Medical University from January 2023 to June 2024 were selected as the research subjects. They were divided into 4 groups (Control group, PBL-CBL group, PBL group and CBL group) using the random number table method, with 60 students in each group.

The control group included 30 males and 30 females, aged 21 to 24 years, with an average age of (22.30 ± 1.12) years; PBL-CBL group included 25 males and 35 females, aged 21 to 24 years, with an average age of (22.56 ± 1.19) years; PBL group included 19 males and 41 females, aged 21 to 24 years, with an average age of (22.28 ± 1.06) years; CBL group included 29 males and 31 females, aged 21 to 24 years, with an average age of (22 ± 0.3) years. As shown in **Table 1**, there were no statistically significant differences in gender and age among the four groups of students ($P > 0.05$).

2.2. Methods

All four groups of students received orthopedic teaching in our institution, adhering

Table 1. Baseline.

Variable	Control (n = 60)	PBL group (n = 60)	CBL group (n = 60)	PBL-CBL group (n = 60)	*P*
Gender					0.166
Male	30 (50.0)	19 (31.7)	29 (48.3)	25 (41.7)	
Female	30 (50.0)	41 (68.3)	31 (51.7)	35 (58.3)	
Age (yr)	22.4 ± 1.2	22.5 ± 1.1	22.6 ± 1.3		0.343

to identical syllabi and teaching durations. The corresponding instructional tasks were uniformly conducted by the same instructor who holds a university teaching certification.

2.2.1. Control group (LBL Group)

The traditional LBL teaching method was adopted. Clinical teaching teachers lectured probationers on basic knowledge related to orthopedics, orthopedic physical examination, and relevant treatment methods. The teaching staff, syllabus, and teaching duration of the control group were the same as those of the experimental groups. Finally, the same written exams and operational assessments were used to evaluate students' competencies. Students evaluated the teaching through online questionnaires.

2.2.2. PBL-CBL Group

In PBL-CBL group, the PBL-CBL teaching method was adopted. Before class, based on clinical practice and teaching experience, the teaching instructor selects and designs typical clinical cases and questions that match the content of the internship. Students were required to preview the cases and related questions by independently consulting literature and reviewing textbooks. During class, the instructor first systematically elaborated on the planned cases in the form of a simulated medical record scenario. The core knowledge points were strung together through questioning to guide students to gradually deepen their understanding of theoretical knowledge and clinical application ability during the process of analysis, discussion, and question answering. Then bedside teaching was carried out. Typical cases in the department that were consistent with or similar to the course content were selected to guide students in conducting standardized medical history taking, physical examinations, etc. The relevant knowledge points were systematically sorted out and summarized in combination with clinical practice (**Figure 1**).

2.2.3. PBL Group

In the PBL group, the PBL teaching method was adopted. Before class, the teaching instructor, based on clinical practice and teaching experience, screened and designed a series of questions that matched the content of the internship. Students were required to preview the relevant questions by reviewing textbooks. During class, the instructor connected the core knowledge points through questioning, guiding students to gradually deepen their understanding of theoretical knowledge

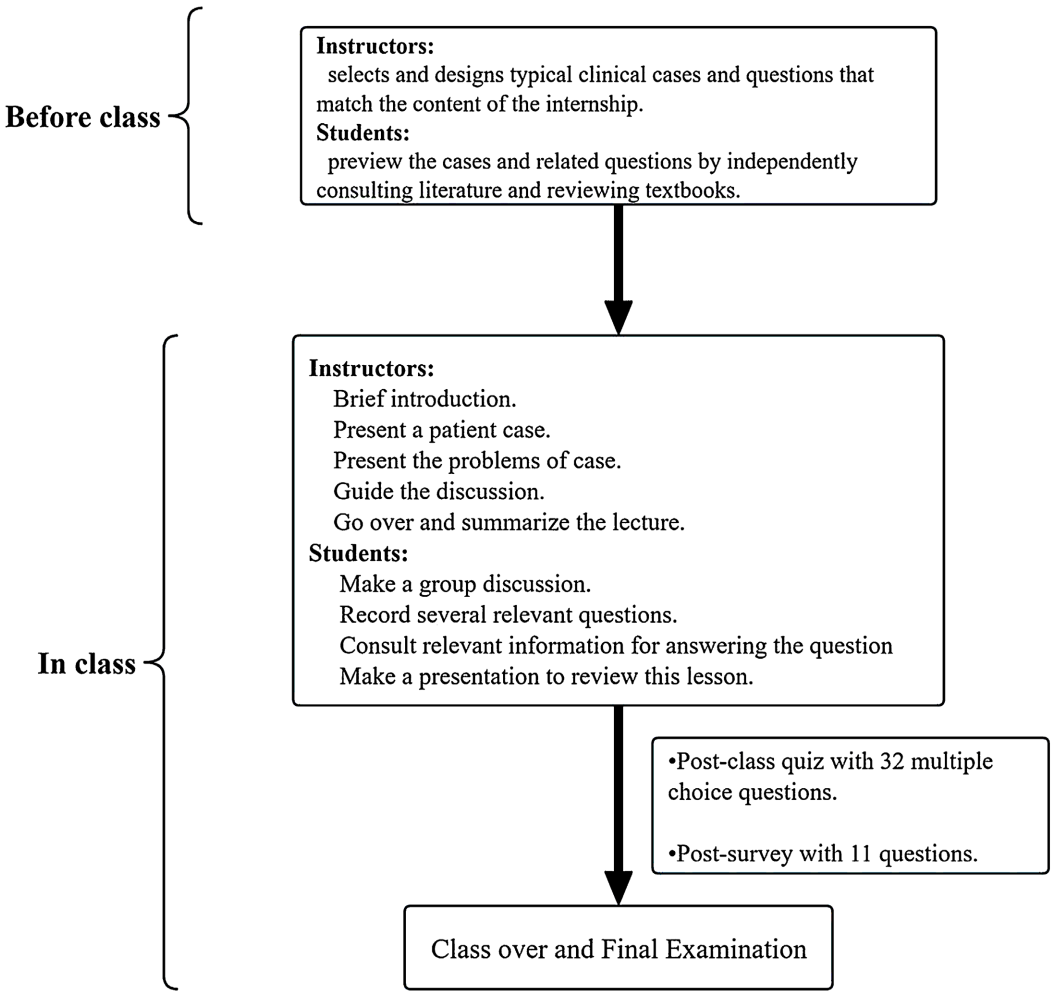

Figure 1. An overview of the PBL-CBL study design.

and clinical application ability during the process of analysis, discussion, and question answering. Then bedside teaching was carried out. Typical cases that were consistent with or similar to the course content in the department were selected to guide students in conducting standardized medical history taking, physical examinations, etc. And the relevant knowledge points were systematically sorted out and summarized in combination with clinical practice.

2.2.4. CBL Group

In the CBL group, the CBL teaching method was adopted. Before class, the teaching instructor selected and designed typical clinical cases that met the content of the internship based on clinical practice and teaching experience. Students were required to preview the cases by independently consulting literature, reviewing textbooks, etc. During class, the instructor first systematically elaborated on the planned cases in the form of a simulated medical record scenario to gradually deepen the understanding of theoretical knowledge and clinical application ability. Then bedside teaching was carried out. Typical cases in the department that were consistent with or similar to the course content were selected to guide students in conducting standardized history taking, physical examinations, etc. And relevant knowledge points were systematically sorted out and summarized in combination with clinical practice.

2.3. Outcome Indicators

2.3.1. Comprehensive Score

After the completion of the teaching, a comprehensive assessment of students was carried out through a standardized written examination (the test questions are drawn from the Chinese Medical Education Question Bank of People's Medical Publishing House) and a clinical skills operation assessment (evaluate using the Objective Structured Clinical Evaluation (OSCE) [12]). The full score of the comprehensive score is 100 points (60 points for the written examination and 40 points for the operation). The higher the score, the more significant the advantages of the teaching method are indicated.

2.3.2. Teaching Satisfaction

After the teaching session was over, organize students conducted an evaluation of teaching effectiveness using an online evaluation system (the evaluation questionnaire is from a self-designed questionnaire of Guangxi Medical University). The evaluation results are presented in the form of scores, with a full score of 100 points. The evaluation content covers six aspects in total, including the impact of the course on the improvement of personal abilities; the diversity of teaching activities; the richness of learning resources; whether the assessment and evaluation system is diversified; the timeliness and effectiveness of the teacher's feedback on students' problems in learning; and the impact of the course on career planning and personal development. The higher the score, the higher the teaching satisfaction. For the detailed evaluation content, please refer to the supplementary materials.

2.4. Statistical Methods

SPSS 25.0 software was used for statistical analysis. Measurement data were expressed as mean ± standard deviation ($\bar{x} \pm s$). For the comparison between groups, one-way analysis of variance was used when the variances were homogeneous. For further pairwise comparisons, LSD-t test was applied. When the variances were heterogeneous, Tamhane test was used. Enumeration data were expressed as the number of cases (n) and percentage (%). The χ^2 test was used for the comparison between groups. P value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of Various Achievements

In the four groups of comparisons, the average scores of written examination, practical operation assessment and comprehensive performance of the PBL-CBL group were higher than those of the other three groups ($P < 0.05$). There were no significant differences in the written examination scores, practical operation scores and comprehensive scores between the PBL group and the CBL group ($P > 0.05$). The written examination scores, practical operation scores and comprehensive scores of the three experimental groups were all higher than those of the control group ($P < 0.05$). For details, please refer to Table 2.

3.2. Comparison of Teaching Satisfaction

There were statistically significant differences in the teaching satisfaction scores among the control group, the PBL-CBL group, the PBL group, and the CBL group (all $P < 0.05$). Among them, the score of the PBL-CBL group was higher than that of the PBL group and the CBL group. The score of the PBL group was higher than that of the CBL group, while the score of the LBL group was the lowest. For details, please refer to Table 2.

Table 2. A comparison of the comprehensive scores and teaching satisfaction of four groups.

Group	n	Written Examination	Practical Operation Assessment	Comprehensive Performance	Teaching Satisfaction scores
Control	60	$47.8 \pm 2.2^{\#\$}$	$31.8 \pm 1.6^{\#\$}$	$79.6 \pm 3.7^{\#\$}$	$90.8 \pm 2.0^{*\#}$
PBL	60	$55.2 \pm 2.4^{*}$	$36.7 \pm 1.6^{*}$	$91.9 \pm 4.0^{*}$	$93.55 \pm 0.8^{*\$}$
CBL	60	$55.0 \pm 2.1^{*}$	$37.2 \pm 1.7^{*}$	$92.2 \pm 3.0^{*}$	$92.7 \pm 0.5^{\#\$}$
PBL-CBL	60	$57.2 \pm 0.5^{*\#\$}$	$38.2 \pm 0.4^{*\#\$}$	$95.4 \pm 0.9^{*\#\$}$	$95.3 \pm 2.3^{*\#\$}$
F/χ^2 value		261.448	241.133	295.054	84.322
P value		<0.001	<0.001	<0.001	<0.001

Note: Compared with the LBL group, $^{*}P < 0.05$; Compared with the PBL group, $^{\#}P < 0.05$; Compared with the CBL group, $^{\$}P < 0.05$.

4. Discussion

Against the backdrop of the continuous deepening of medical education reform, orthopedics, as a highly practical discipline in clinical medicine, has become a key discipline area for development in medical education [13]. With the continuous improvement of the standards for medical talent cultivation, the traditional Lecture-Based Learning (LBL) teaching method, which mainly relies on teacher lectures, is gradually showing limitations in cultivating students' clinical practice abilities [14]. It is difficult to meet the requirements of cultivating compound talents in medical education in the new era. In recent years, new teaching methods represented by Problem-Based Learning (PBL) and Case-Based Learning (CBL) have received extensive attention in the field of medical education due to their significant advantages in stimulating students' enthusiasm for active learning and enhancing their clinical thinking abilities [15] [16]. The core educational principles of PBL revolve around self-directed learning, problem-solving competency, and collaborative knowledge construction. By simulating real-world complex problems, PBL stimulates learners' intrinsic motivation, prompting them to actively engage in knowledge exploration. During the PBL process, students engage in discussions centered on open-ended questions, formulate hypotheses, and seek solutions—a cycle that not only cultivates critical thinking but also strengthens teamwork and communication skills. The theoretical foundation of PBL aligns with constructivist learning theory, which posits that knowledge is actively constructed through individual interactions with the environment rather than passively received. In contrast, CBL emphasizes structured exposure to authentic patient cases, integrating theoretical knowledge into clinical decision-making frameworks through case analysis. The pedagogical tenets of CBL underscore the development of situated learning and clinical reasoning abilities. By leveraging real or simulated clinical scenarios, CBL assists students in comprehending disease pathogenesis, diagnostic reasoning, and therapeutic strategies, thereby bridging the theory-practice gap. While also rooted in constructivism, CBL places greater emphasis on guiding learners to progressively develop clinical thinking systems through concrete case analyses. However, both the pure PBL and CBL teaching models have defects [8] [9]. Compared to traditional teaching methods, PBL may demonstrate relatively lower efficiency in imparting systematic knowledge. Students might prioritize problem-solving processes while overlooking the comprehensive mastery of all knowledge points, potentially resulting in fragmented or superficial understanding. In addition, CBL courses usually require a high level of student participation. However, the lack of interactive methods may turn CBL courses into a "one-man show" by the teacher. In order to break through the inherent bottleneck of a single teaching method and achieve complementary advantages, some scholars have proposed a collaborative teaching strategy of PBL and CBL. By creating a situational context of clinical cases to enhance the sense of immersion in learning and strengthening knowledge summary through questioning, students can deepen their understanding of knowledge points, thus realizing the innovation of teaching methods and effectively optimizing the scientific nature and systematicness of the teaching process [17]. However, the teaching model combining PBL and CBL is still rarely applied in orthopedic probation teaching.

In order to verify whether the PBL-CBL teaching model is feasible, we carried out this research. The findings of this study demonstrate that the integration of PBL and CBL into orthopedic clinical teaching yields superior outcomes compared to traditional LBL, as evidenced by significantly higher exam scores (written examination, practical operation assessment and comprehensive performance) and teaching satisfaction scores in the PBL-CBL group. These results align with the growing body of literature advocating for constructivist pedagogical approaches in medical education, which emphasize active learning, critical thinking, and contextual application of knowledge [18] [19].

The superior performance of the PBL-CBL group may be attributed to the synergistic effects of combining two complementary methodologies. PBL, by design, fosters self-directed learning, problem-solving skills, and collaborative knowledge construction through open-ended clinical scenarios. Meanwhile, CBL provides structured exposure to authentic patient cases, enabling learners to contextualize theoretical concepts within clinical decision-making frameworks. Under the guidance of open-ended questions in PBL, students initially conduct extensive literature research and collaborative discussions to develop an initial understanding of the problem and generate multiple potential solutions. This process cultivates students' spirit of exploration and fosters innovative thinking. Subsequently, CBL facilitates the application of theoretical knowledge to clinical scenarios through in-depth analysis of specific cases, enabling students to verify and refine their initial hypotheses. This iterative process enhances the accuracy and efficiency of clinical reasoning while developing systematic clinical thinking patterns. The structured case analysis framework provided by CBL offers students a clear cognitive scaffold, facilitating the consolidation of theoretical concepts into practical clinical decision-making competencies. The integration of these approaches likely creates a "scaffolded" learning environment where students first engage in exploratory problem-solving (PBL) and subsequently refine their clinical reasoning through guided case analysis (CBL). This dual-exposure model may enhance knowledge retention and transferability to real-world clinical settings, as suggested by the improved examination outcomes (**Table 2**).

Notably, while both PBL and CBL groups individually outperformed the LBL control group, neither demonstrated significant advantages over the other. The lack of difference between PBL and CBL in our study could reflect the specificity of orthopedic content, where case-based reasoning may inherently align with procedural and diagnostic workflows. However, the PBL-CBL combination's clear superiority underscores the value of sequential pedagogical layering—first stimulating curiosity and hypothesis generation (PBL), then refining diagnostic precision through case-specific iterations (CBL).

Student evaluations further corroborated the quantitative results (**Table 2**), with the PBL-CBL group reporting higher satisfaction regarding engagement, clinical relevance, and skill development. This aligns with qualitative research highlighting learners' preference for pedagogies that bridge the theory-practice gap. The bedside teaching component, which operationalized case-based principles through direct patient interaction, likely contributed to these perceptions by emphasizing the practical utility of acquired knowledge.

Despite the numerous advantages of the integrated PBL-CBL model, its implementation may encounter certain challenges. PBL-CBL model necessitates additional teaching resources, including meticulously designed cases, experienced instructors, and appropriate instructional spaces. These resource demands may pose challenges for medical institutions with limited resources. To address this, medical institutions could collaborate with educational institutions and industry partners to jointly develop and share teaching resources, thereby alleviating the resource burden on individual institutions. The successful implementation of PBL-CBL hinges on effective facilitation by instructors. Educators require specialized training to master skills in problem design, discussion facilitation, and feedback provision. Inadequate instructor training may compromise teaching effectiveness. Consequently, establishing a systematic training program and certification system is crucial to ensure that instructors possess the requisite competencies for implementing PBL-CBL, thereby enhancing teaching quality. Furthermore, the limitations of this study include its single-center design and reliance on subjective student evaluations, which may introduce response bias. Therefore, the evaluation of the PBL-CBL teaching model's effectiveness necessitates supplementation through multi-center studies and validation via long-term teaching practices.

5. Conclusion

In conclusion, the PBL-CBL hybrid model represents an effective educational strategy for orthopedic clerkships, offering a structured yet flexible framework to cultivate clinical competence. As medical education continues to evolve toward competency-based paradigms, such integrated approaches warrant broader implementation and investigation across diverse clinical disciplines.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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