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Application of the Case-Based PBL Teaching Model in Clinical Microbiology Laboratory Internship Teaching

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Abstract: *Objective:* To explore the application effect of the case-based problem-based learning (PBL) teaching model in clinical microbiology laboratory internship teaching, and provide a reference for the reform of clinical practical teaching. *Methods:* A total of 36 students who interned in the Clinical Laboratory of the Affiliated Hospital of Youjiang Medical University for Nationalities from May 2023 to April 2025 were selected as the research subjects. They were divided into two groups by the envelope method, with 18 students in each group. The control group adopted the traditional lecture-based teaching model, while the study group used the case-based PBL teaching model. The teaching scores, teaching quality, and satisfaction of the two groups of interns were compared. *Results:* The theoretical score (65.28 ± 2.78), skill score (26.06 ± 2.34), and total score (91.33 ± 3.54) of the study group were all higher than those of the control group (61.67 ± 3.01, 22.28 ± 2.49, 83.94 ± 3.72, respectively), and the differences were statistically significant ($P < 0.05$). The results of the questionnaire showed that the scores of students in the study group in terms of autonomous learning, clinical thinking ability, comprehension ability, and learning interest were significantly higher than those in the control group, and all the differences were statistically significant ($P < 0.05$). Meanwhile, the satisfaction rate of students in the study group with the teaching was significantly higher than that in the control group, and the difference was statistically significant ($P < 0.05$). *Conclusion:* The PBL teaching model can effectively improve the academic performance of interns and the quality of teaching, enhance teaching satisfaction, and thus serve as a powerful auxiliary teaching method in clinical internship education.

Keywords: Problem-based learning; Reform; Internship teaching; Clinical microbiology laboratory

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1. Introduction

Clinical microbiology laboratory internship teaching is a crucial component of medical education, playing a

vital role in cultivating students' practical abilities, clinical thinking, and the capacity to translate theoretical knowledge into practical operation. Through internship teaching, students can gain an in-depth understanding of the workflow in clinical microbiology laboratories, master detection and identification techniques for various pathogens, and lay a solid foundation for future clinical laboratory work [1]. Traditional clinical microbiology internship teaching often adopts a teacher-centered, lecture-based model, focusing on knowledge impartation, with students in a passive receiving state. While this approach enables students to acquire certain foundational knowledge, they often lack independent thinking, analytical, and problem-solving skills when facing complex and variable clinical practical problems [2]. Furthermore, case updates are often untimely in traditional teaching, making it difficult for students to be exposed to the latest clinical cases and advances in testing technology, leading to a disconnect between what is learned and clinical practice [3]. Additionally, students have fewer opportunities for teamwork in traditional teaching, which is not conducive to cultivating teamwork spirit and communication skills, abilities that are essential in clinical work.

In 1969, McMaster University Medical School in the United States pioneered and implemented problem-based learning (PBL) as a core teaching method. Its essence is to use "problems" as the starting point for learning, allowing students to explore real or simulated clinical problems, rather than merely memorizing theory. Since then, this teaching method has gradually expanded from the medical field to various disciplines such as engineering and business, becoming an important direction in global education reform. Related research confirms that the PBL teaching method can effectively enhance students' learning motivation and initiative, while further stimulating their innovative thinking and experimental exploration awareness [4,5]. We introduced the case-based PBL teaching model into clinical microbiology internship teaching, centering on real clinical infectious disease cases and designing problems around key links such as sample collection, microbial isolation and identification, interpretation of drug susceptibility test results, and clinical medication guidance. This guides students to raise questions, analyze problems, and seek solutions, cultivates their clinical thinking and problem-solving abilities, enhances their teamwork, communication, and autonomous learning capabilities, enables them to better adapt to the demands of future clinical work, improves the quality of clinical microbiology internship teaching, and cultivates more outstanding professionals for the healthcare industry.

2. Subjects and methods

2.1. General information

A total of 36 students who interned in the Clinical Laboratory of the Affiliated Hospital of Youjiang Medical University for Nationalities from May 2023 to April 2025 were selected as the research subjects. They were divided into two groups by the envelope method, with 18 students in each group. The control group included 5 males and 13 females, aged 18–23 years, with an average age of 21.03 ± 0.22 years. The study group included 6 males and 12 females, aged 18–22 years, with an average age of 20.95 ± 0.25 years. There was no statistically significant difference in the general information between the two groups of interns ($P > 0.05$). This study met medical ethics requirements, and all subjects were informed and voluntarily cooperated with the teaching research project.

2.2. Inclusion and exclusion criteria

Inclusion criteria: Interns in the clinical laboratory of our hospital; age 18–23 years; agreement to participate in this study.

Exclusion criteria: Inability to cooperate or withdrawal from the study; inability to communicate effectively; having received relevant internship training previously.

2.3. Methods

The teaching content was the same for both the study group and the control group, and the same teaching faculty was used.

The control group adopted the traditional teaching model. Traditional intern teaching included guiding interns in the isolation, culture, and identification of common pathogens in the microbiology laboratory, as well as skills such as drug susceptibility testing, Gram stain morphological microscopy, and serological testing, while emphasizing the importance of aseptic technique. Theoretical knowledge and practical operation abilities were consolidated through weekly special lectures and regular assessments. The teaching duration was 8 class hours.

The study group adopted the case-based PBL teaching method. Teachers selected clinical cases that were typical, complex, and inspiring. Students raised questions based on the cases, divided tasks, and collaborated to find answers by consulting professional textbooks, clinical laboratory operating procedures, academic literature, and database resources such as Wanfang Medical Network and CNKI. Teachers play the role of guides and answerers throughout the process. Teachers participated in student discussions, observed the progress of discussions, and provided timely guidance and inspiration. When students encountered bottlenecks in problem analysis, teachers used questioning to guide students to think from different perspectives and help them clarify their thoughts. After a period of discussion and research, students needed to create PPTs to present their achievements. The presentation content included the case analysis process, proposed diagnostic hypotheses, designed testing procedures, and expected results etc. Student representatives needed to clearly articulate their viewpoints and reasoning during the presentation, and other members could provide supplements and ask questions. After the presentation, both the teacher and the other students participated in the evaluation. The evaluation content included the accuracy of problem analysis, the rationality of solutions, the logic of the presentation, and communication skills. The teacher also provided a comprehensive evaluation of the students' performance throughout the process, such as teamwork ability, communication skills, and autonomous learning ability.

2.4. Teaching effect evaluation

(1) Teaching scores: Included theoretical and skills examinations. The theoretical knowledge section was worth 70 points, and the operational skills section was worth 30 points. The theoretical examination consisted of multiple-choice questions, fill-in-the-blank questions, and short-answer questions. The operational skills required students to list the culture and identification process for a given case, correctly select culture media, record bacterial growth observations, perform Gram staining, operate the mass spectrometer correctly, isolate single colonies on plates, and report identification results. The scores of the theoretical and skills examinations for the study group and the control group were compared to analyze the teaching effects of the two groups.

(2) Teaching quality: A self-made questionnaire was used to evaluate the teaching quality for both groups of interns. The content included four aspects: students' autonomous learning, clinical thinking ability, comprehension ability, and learning interest. Each aspect was scored out of 100 points, with higher scores indicating better teaching quality. The questionnaire scores of the two groups were analyzed.

(3) Teaching satisfaction: A self-made questionnaire was used, based on a percentage system. A score of ≥80 was considered very satisfied, 60–80 was generally satisfied, and <60 was dissatisfied. Total satisfaction rate = (Number of very satisfied + Number of generally satisfied) / Total number × 100%.

2.5. Statistical methods

SPSS 21.0 statistical software was used for data processing. The Kolmogorov-Smirnov test was used to assess

data normality. The count data were analyzed using the χ^2 test. Measurement data were expressed as mean ± standard deviation (SD), and comparisons between the two groups were performed using an independent samples *t*-test. A *P*-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of teaching scores between the two groups

The theoretical examination scores, skill scores, and total scores of the students in the study group were all higher than those in the control group, and the differences were statistically significant ($P < 0.05$), as shown in **Table 1**.

Table 1. Comparison of teaching scores between the two groups (mean ± SD, points)

Group	Theoretical score	Skill score	Total score
Control group ($n = 18$)	61.67 ± 3.01	22.28 ± 2.49	83.94 ± 3.72
Study group ($n = 18$)	65.28 ± 2.78	26.06 ± 2.34	91.33 ± 3.54
t	3.738	4.690	6.100
P	0.001	< 0.001	< 0.001

3.2. Comparison of teaching quality between the two groups

The scores of the students in the study group regarding autonomous learning, clinical thinking ability, comprehension ability, and learning interest were all higher than those in the control group, and the differences were statistically significant ($P < 0.05$), as shown in **Table 2**.

Table 2. Comparison of teaching quality between the two groups (mean ± SD, points)

Group	Autonomous learning	Clinical thinking	Comprehension	Learning interest
Control group ($n = 18$)	73.16 ± 6.01	76.78 ± 5.70	75.28 ± 6.68	73.17 ± 6.49
Study group ($n = 18$)	85.17 ± 4.59	87.56 ± 3.38	88.61 ± 4.55	88.33 ± 3.76
t	6.730	6.896	6.995	8.578
P	< 0.001	< 0.001	< 0.001	< 0.001

3.3. Comparison of teaching satisfaction between the two groups

The total satisfaction rate of the study group was higher than that of the control group, and the difference was statistically significant ($P < 0.05$), as shown in **Table 3**.

Table 3. Comparison of teaching satisfaction between the two groups [*n* (%)]

Group	Very satisfied (*n*)	Generally satisfied (*n*)	Dissatisfied (*n*)	Total satisfaction rate (%)
Control group ($n = 18$)	3	9	6	66.67
Study group ($n = 18$)	8	10	0	100.00
P				0.042

Note: Total satisfaction rate = (Number of very satisfied + Number of generally satisfied) / Total number × 100%.

4. Discussion

Clinical microbiology laboratory technology is a discipline that highly integrates laboratory science with clinical medicine, particularly with infectious diseases. The microbiology course involves a microscopic world characterized by numerous and complex pathogen names, diverse biochemical reactions, and a wide variety of identification tests. This makes the knowledge points seem scattered and fragmented, with weak interconnections, and the content is relatively abstract [6]. These characteristics pose significant difficulties for students' memorization and summarization and are not conducive to the cultivation of their clinical thinking ability, consequently making it difficult for traditional small-lecture teaching to achieve ideal results. Therefore, there is an urgent need to innovate teaching models to enhance teaching effectiveness. Through innovative teaching models, the aim is to comprehensively enhance interns' theoretical knowledge level and operational practical ability, cultivate their clinical communication awareness, and thereby improve their overall quality during the relatively short internship period, enabling them to better adapt to the development needs of clinical laboratories under the background of the "New Medicine" strategic development.

The core advantages of the PBL teaching model are reflected in: on one hand, stimulating the learning initiative of interns and promoting active participation; on the other hand, guiding through case clues to promote the application and integration of theoretical knowledge, achieving the transformation from "knowing" to "using" [7]. Based on the short duration of microbiology internships and the characteristics of microbiological testing, PBL teaching can quickly exert the role of diverse teaching modes, ensuring the completion of the internship plan. The results of this study showed that the students in the study group significantly outperformed the control group in theoretical scores, skill scores, and total scores, and the differences were statistically significant. This result indicates that the teaching reform measures are highly effective in deepening students' understanding of theoretical knowledge. The traditional teaching model mostly relies on one-way knowledge impartation by teachers, with students passively receiving knowledge, making it difficult to form a systematic knowledge framework. In contrast, the interactive, case-based teaching methods adopted after the reform guide students to think actively and combine theoretical knowledge with practical problems, thereby improving theoretical learning outcomes. Regarding skill scores, the average score of the study group was higher than that of the control group, and the improvement in skill scores even exceeded that in theoretical scores, which fully demonstrates the educational reform's emphasis on cultivating students' practical abilities. In traditional teaching, practical teaching links often became formalities, with students lacking sufficient hands-on opportunities. After the reform, practical teaching hours were increased, and simulated training bases were established, allowing students to practice skill operations in realistic scenarios, accompanied by guidance from professional teachers to correct operational errors promptly, effectively enhancing students' skill levels. In terms of total scores, the average score of the study group far exceeded that of the control group. This comprehensive data further verifies the overall effectiveness of the teaching reform. The comprehensive improvement in academic performance not only reflects the synchronous development of students' knowledge and skills but also indicates that the teaching reform measures align with students' learning patterns and cognitive characteristics. It can fully mobilize students' learning enthusiasm and lay a solid foundation for students' future development.

Besides academic performance, the teaching reform is also significant for enhancing students' comprehensive abilities. This study showed that the scores of the study group in the four dimensions of autonomous learning, clinical thinking ability, comprehension ability, and learning interest were all significantly higher than those of the control group, and the differences were statistically significant. Regarding autonomous learning ability, the average score of the study group was higher than that of the control group. This indicates

that the teaching reform, by introducing project-based learning, online autonomous learning platforms, etc., successfully cultivated students' autonomous learning awareness and ability. Students no longer relied solely on teachers' supervision but were able to formulate learning plans based on their own learning needs, actively consult materials, and solve problems, forming good learning habits. Clinical thinking ability is one of the core competencies essential for medical students. The average score of the study group in this dimension was higher than that of the control group, suggesting that during the teaching reform process, through teaching activities such as extensive clinical case analysis, students learned to proceed from clinical practice, use acquired knowledge to analyze, judge, and manage clinical situations, and gradually formed a scientific clinical thinking mode, effectively shortening the adaptation period from theoretical learning to clinical practice. Regarding comprehension ability, the research data indicate that the layered teaching and group cooperative learning methods adopted in the teaching reform could develop personalized teaching plans tailored to students with different learning levels, helping students better understand complex knowledge content and improve knowledge application ability. The significant enhancement of learning interest is an important marker of the teaching reform's success. Interest is the best teacher. The teaching reform, by enriching teaching content, innovating teaching methods, and creating a positive classroom atmosphere, made learning no longer dull and fully stimulated students' learning enthusiasm, transforming them from being "required to learn" to "wanting to learn."

Student satisfaction is an important indicator for measuring the effectiveness of teaching reform. The survey results showed that the total satisfaction of students in the study group with the teaching reform was higher than that of the control group, fully indicating students' recognition and support for the teaching reform measures. The improved learning outcomes and enhanced learning experience brought about by the reform allowed students to tangibly feel their own growth and progress, thereby generating a high level of identification with the teaching reform. The dissatisfaction of 6 students in the control group might be due to the traditional teaching model's inability to meet students' diverse learning needs, resulting in low learning motivation and poor learning outcomes. The absence of dissatisfaction in the study group further proves that the teaching reform measures can fully consider students' needs and feelings, optimizing and refining various aspects such as teaching content, teaching methods, and teaching evaluation, thereby providing students with higher-quality educational services.

Although this teaching reform experiment achieved significant results, certain limitations remain. First, the sample size of this study was small, involving only 36 students from the same major, potentially limiting the representativeness of the sample. Future research should expand the sample size to include students from different majors and grades to improve the universality and reliability of the findings. Second, the observation period of this study was relatively short, only evaluating students' short-term academic performance, comprehensive abilities, and satisfaction. It cannot fully reflect the long-term impact of the teaching reform on students' development. Follow-up long-term tracking surveys should be conducted to observe students' performance in employment and career development. Furthermore, this teaching reform involved multiple measures, and the specific effect of any single measure could not be analyzed separately. Future studies could further refine the research to clarify the mechanism and effect differences of various teaching reform measures, providing more precise guidance for the deepening of teaching reform. In summary, this teaching reform experiment provides a useful reference for education and teaching reform. Based on the existing research, teaching reform measures should be continuously optimized and improved in the future to promote the sustained enhancement of education quality and make greater contributions to cultivating more high-quality talents.

5. Conclusion

The case-based PBL teaching model significantly enhances theoretical and practical performance, improves teaching quality in areas such as autonomous learning, clinical thinking, comprehension, and interest, and increases student satisfaction compared to traditional lecture-based methods in clinical microbiology laboratory internship teaching. Therefore, the PBL model serves as an effective and valuable supplementary approach in clinical internship education.

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Disclosure statement

The authors declare no conflict of interest.

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