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Effectiveness of PBL Pedagogy Combined with Flipped Classroom in the Standardized Training of Resident Physicians

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Abstract: *Objective*: To analyze the application effect of the problem-based learning (PBL) teaching method combined with flipped classrooms in the standardized training of gastroenterology residents. *Methods*: Sixty-five resident trainees who were admitted to the Department of Gastroenterology of the hospital from January to December 2023 were selected and divided into the control group (n = 33) and the observation group (n = 32) by random number division method. The control group implemented the traditional clinical teaching method, and the observation group implemented the PBL combined flipped classroom teaching method. The study compared the two groups' discharge learning performance, trainees' subjective feeling score, and teaching satisfaction score index. *Results*: The difference in basic knowledge scores between the two groups of trainees under different teaching modes was not statistically significant ($P > 0.05$). However, the observation group was significantly higher than the control group in terms of the differences in case analysis, clinical operation skills, and total scores, and the differences were statistically significant ($P < 0.05$). The trainees of the observation group were more satisfied with the teaching and learning process in terms of learning efficiency, clinical thinking, communication, faculty-student collegiality, teamwork, self-study ability, classroom atmosphere, independent learning, clinical thinking and other subjective feelings of the scores are higher than the control group, the difference is statistically significant ($P < 0.05$). The observation group teaching total satisfaction rate is 96.87%, significantly higher than the control group's 75.75% ($P < 0.05$). *Conclusion*: The application of the PBL teaching method combined with flipped classroom in the standardized training of residents is effective, which can not only significantly improve the basic theory and practical operation performance of the trainees, but also help to improve their case analysis ability, clinical thinking ability, and doctor-patient communication ability, so it is worthwhile to popularize its application in the clinical scope.

Keywords: Flipped classroom; PBL; Clinical practice teaching; Teaching effectiveness

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1. Introduction

Gastroenterology has a wide variety of diseases, involving a wide range of organs and systems, and cases are often complex and changeable, requiring clinicians not only to have solid theoretical knowledge but also to have a high degree of clinical judgment and flexible treatment skills. Therefore, focusing on standardized residency training, cultivating physicians' professional skills, and improving their clinical diagnosis and treatment level through systematic education and practice can ensure that patients can receive high-quality medical services. However, the traditional clinical teaching method mainly relies on the experience transfer and on-site guidance of the teaching faculty. Although this model has certain advantages in basic knowledge and practical operation, it is deficient in cultivating residents' independent learning ability, critical thinking, and ability to solve complex problems [1]. Due to the limitations of clinical resources and faculty, the traditional clinical teaching method often fails to adequately meet the different learning needs and progress of each resident, and this one-to-many teaching model makes it difficult to provide personalized guidance and feedback to each resident, limiting the in-depth development of their professional skills and knowledge. The introduction of the problem-based learning (PBL) teaching method and the flipped classroom teaching model provides a new way of thinking to solve these problems. The PBL teaching method cultivates problem-solving ability and lifelong learning ability by guiding the trainees to engage in self-directed learning and teamwork around actual clinical problems. The flipped classroom model, on the other hand, utilizes classroom time more effectively using pre-course self-study and in-depth classroom discussion and promotes trainees' active learning and critical thinking [2]. Therefore, introducing the PBL teaching method combined with the flipped classroom model into the standardized training of gastroenterology residents can not only make up for the shortcomings of the traditional teaching method but also more comprehensively improve the clinical ability and professionalism of the residents. This combination of teaching modes is in line with the development trend of modern medical education and has important practical significance and long-term value for improving the comprehensive quality and clinical treatment ability of gastroenterology residents.

2. Objects and methods

2.1. Objects of study

Sixty-five regulatory trainees who were admitted to the Department of Gastroenterology in the hospital from January to December 2023 were selected and divided into the control group (n = 33) and the observation group (n = 32) by random number division method. In the control group, there were 18 males and 15 females, with an age range of 21 to 25 years old and a mean of 22.24 ± 1.46 years old, and the admission scores (basic knowledge scores + case analysis + clinical skills) are 63.39 ± 7.72 for the PBL teaching method. In the observation group, there were 19 males and 13 females, age range of 20–25 years old, an average of 22.09 ± 1.56 years old, an admission score (basic knowledge + clinical skills) of 63.39 ± 7.72 for the PBL teaching method and a case analysis score + clinical operation skill score of 63.42 ± 7.68. PBL combined with the flipped classroom teaching method was implemented. Both groups of trainees met the requirements of standardized residency training and voluntarily participated in this teaching experiment.

2.2. Methodology

The traditional clinical teaching method was implemented in the control group. Trainees learn in a real clinical environment by directly observing the diagnostic and therapeutic operations of the instructor, participating in

case discussions, completing assigned clinical tasks and surgical assistants, and acquiring the necessary medical skills and clinical decision-making abilities through imitation, practice, and repeated operations.

The PBL + flipped classroom joint teaching method was implemented in the observation group as follows.

2.2.1. Pre-course preparation

Teachers prepare video lectures, professional articles, clinical guidelines, and other related learning materials in advance for students' self-study to master the key knowledge points such as the etiology, pathogenesis, diagnostic criteria, symptomatic manifestation, and complication prevention of common diseases in gastroenterology through reviewing the latest medical literature, guidelines, and related medical database information, to make sufficient preparation for theoretical knowledge.

2.2.2. Asking questions

Teachers design teaching questions according to the standardized training syllabus for gastroenterology residents, inspire students to carry out self-exploration with the questions, guide students to think deeply about the clinical case data, and ask deeper questions in exploring the answers to further deepen the understanding of the basic knowledge and problem-solving ability exercise.

2.2.3. Organize discussions

Based on the students' thorough preparation, classroom time is mainly used for in-depth discussions, problem-solving, practical simulations or case studies, and other activities. Students are encouraged to speak boldly, share their views and insights, and closely integrate theoretical knowledge with clinical practice to deepen their understanding of gastroenterology diagnosis and treatment knowledge while improving their ability to analyze and solve problems. Teachers play the role of guide and coordinator in this process and promote in-depth thinking and communication by asking questions, and challenging or introducing new cases. It should be noted that the teacher needs to respond to the problems raised by the students promptly, evaluate the solutions provided by the students, and, if necessary, correct the students' erroneous viewpoints to avoid running off the topic and to ensure the scientific and practical nature of the discussion activities.

2.2.4. Summarization

After the discussion, the participants' representatives summarize the results of the discussion, including answering the initial questions, pointing out the unresolved difficulties, and introducing new issues. For further discussion of unresolved or newly raised issues, the teacher should provide more specific guidance and tips to help analyze the problem in depth and seek solutions. Finally, the faculty member summarizes the process, evaluates the trainee's contribution, provides authoritative insights into controversial issues, and gives professional advice on treatment options and clinical learning to ensure that the trainee can apply what he or she has learned in practice and improve clinical decision-making and operational skills.

2.3. Observation indicators

After the completion of the training teaching, the two groups of trainees undergo the learning achievement test. The test content contains basic knowledge, case analysis, and clinical operation skills in three parts, the value of the proportion of 30 points, 30 points, and 40 points in turn, a full score of 100 points. The hospitals make their questionnaire for the research trainees on the subjective feeling of the effect of training. The survey items mainly contain 9 items such as learning efficiency, clinical thinking, communication, teacher-student collegiality, teamwork, self-learning ability, classroom atmosphere, independent learning, clinical thinking, and

so on. The quantitative standard of each item is divided into 4 grades: excellent (5 points); good (4 points); Medium (2 to 3 points); and poor (1 point). Trainees fill in the questionnaire according to their subjective feelings, and it is collected on the spot. Using the questionnaire to investigate students' satisfaction with teaching methods, the questionnaire is anonymous to two groups of students at the same time. A total of 65 questionnaires were issued, and 65 copies were retrieved, a recovery rate of 100%. The satisfaction evaluation test has 3 dimensions, consisting of very satisfied, satisfied, and dissatisfied. Total Satisfaction (%) = (Very Satisfied + Satisfied)/Total x 100%.

3. Results

3.1. Comparison of academic performance between the two groups

There was no statistically significant difference in the basic knowledge scores of the two groups of trainees under different teaching modes ($P > 0.05$). However, the observation group was significantly higher than the control group in terms of the differences in case analysis, clinical operation skills, and overall scores, and the differences were statistically significant ($P < 0.05$), as shown in **Table 1**.

Table 1. Comparison of the academic performance of the two groups of participants (mean ± SD, points)

Groups	*n*	Basics	Case analysis	Clinical skill	Total
Control subjects	33	21.33 ± 2.19	20.02 ± 2.45	32.34 ± 2.78	73.69 ± 7.42
Observation group	32	22.14 ± 2.32	22.69 ± 2.75	35.66 ± 2.62	80.49 ± 7.69
t		1.4479	4.1361	4.9517	3.6283
P		0.1526	0.0001	0.0000	0.0006

3.2. Comparison of subjective feeling scores between the two groups of participants

The scores of trainees in the observation group were higher than those of the control group in terms of learning efficiency, clinical thinking, communication, teacher-student collegiality, teamwork, self-study ability, classroom atmosphere, independent learning, clinical thinking, and other subjective perceptions, and the difference was statistically significant ($P < 0.05$), as shown in **Table 2**.

Table 2. Comparison of subjective feeling scores between the two groups of participants (mean ± SD, points)

Evaluation projects	Control group (*n* = 33)	Observation group (*n* = 32)	*t*	*P*
Learning efficiency	3.04 ± 0.78	3.72 ± 1.13	2.8310	0.0062
Clinical thinking	3.79 ± 0.81	4.17 ± 0.69	2.0331	0.0463
Communication	3.24 ± 0.76	3.96 ± 0.82	3.6731	0.0005
Teacher-student colleague relationship	3.25 ± 0.64	3.89 ± 0.79	3.5941	0.0006
Teamwork	2.79 ± 1.31	3.65 ± 1.24	2.7165	0.0085
Self-learning ability	3.08 ± 1.38	3.95 ± 1.18	2.7279	0.0082
Classroom atmosphere	3.27 ± 0.85	3.97 ± 0.97	3.0970	0.0029
Independent study	2.79 ± 1.05	3.45 ± 1.42	2.1352	0.0366

Clinical thinking	2.99 ± 0.53	4.07 ± 0.39	9.3336	0.0000

3.3. Statistics of satisfaction survey results

The results of the questionnaire suggested that the total satisfaction rate of teaching in the observation group was 96.87%, which was significantly higher than 75.75% in the control group ($P < 0.05$), as shown in **Table 3**.

Table 3. Comparison of the results of the survey on participants' satisfaction with teaching in the two groups [n, (%)]

Group	Very happy	Dissatisfied	Unsatisfactory	Overall satisfaction rate
Observation group ($n = 32$)	20 (62.50)	11 (34.37)	1 (3.13)	31 (96.87)
Control group ($n = 33$)	10 (30.30)	15 (45.45)	8 (24.24)	25 (75.75)
X^2 value				4.4321
P-value				0.0353

4. Discussion

4.1. Advantageous features of PBL joint flipped classroom teaching methodology

The application of problem-based learning (PBL) combined with flipped classroom pedagogy in the standardized training of gastroenterology residents integrates the advantages of two advanced teaching modalities to provide physicians with an innovative learning environment. The core of this integrated pedagogy lies in problem-driven learning while optimizing classroom time by using pre-course self-study materials to promote student-centered problem-solving through independent learning and teamwork to deepen the understanding and application of professional knowledge in gastroenterology. The primary distinguishing feature of the PBL combined flipped classroom pedagogy is the promotion of active learning. Under this joint teaching model, trainee learning is no longer a passive process of receiving knowledge, but a process of active exploration and discovery. In the learning practice, participants are required to independently study designated teaching videos, professional literature, and other materials before the class to help them construct a knowledge framework and stimulate their curiosity and desire for new knowledge [3]. Another major advantage of the PBL co-taught flipped classroom teaching method is to strengthen the cultivation of critical thinking and problem-solving abilities of the participants. Through problem-centered teaching activities, participants enhance their clinical thinking skills through the process of asking questions, analyzing problems, finding solutions, and improving their ability to collaborate in a team and solve complex healthcare problems. PBL with a flipped classroom approach allows for more flexible and student-centered teaching and learning by optimizing the use of classroom time. Classroom time is utilized for activities such as in-depth discussions, case studies, and hands-on practice, which not only improves learning efficiency but also allows each participant to express his/her views in the classroom and participate in the real clinical decision-making process, which greatly enhances the attractiveness and effectiveness of learning. In conclusion, by combining PBL and flipped classroom, gastroenterology residency training can more comprehensively cultivate physicians' clinical competencies, including knowledge application, critical thinking, problem-solving ability, and teamwork and communication skills, thus laying a solid foundation for them to become high-quality medical professionals.

4.2. Application requirements

4.2.1. Requirements for the teaching physician

Under the framework of the PBL joint flipped classroom teaching method, the roles and responsibilities played by the teaching physicians are far beyond the scope of the traditional teaching model, as they are not only the transmitters of knowledge, but also the guides and facilitators of the learning process. First of all, teaching physicians need to have excellent preparation and resource integration ability to ensure that the materials they select and produce such as teaching videos, the latest research articles, and real cases related to the teaching content are scientific and reasonable, highly relevant and practical, which can arouse the interest of residents and motivate them to carry out in-depth study before the class [4]. Secondly, in the PBL and flipped classroom environment, the instructor needs to be able to effectively facilitate classroom discussions, stimulate the collision of ideas among students, and guide them to explore, analyze, and solve practical clinical problems comprehensively. This requires the ability to flexibly utilize a variety of communication skills, including questioning, listening, feedback, and encouragement, to establish an open and mutually respectful learning atmosphere. Finally, as resident students have different learning backgrounds, experiences, and assimilation speeds, the teaching physician needs to have the ability to be sensitive and adaptive to students' progress, to be able to accurately assess each student's learning progress and needs and to flexibly adjust the teaching program and content according to the actual situation. This personalized teaching strategy helps maximize learning outcomes and ensures that each resident has the best possible learning experience and growth in training.

4.2.2. Requirements for resident trainees

Independent study and time management skills: Resident students need to study the provided materials independently before class and manage their study time effectively. Active participation and teamwork: In the classroom, resident students are expected to actively participate in discussions, collaborate with peers to solve problems, and share knowledge and experience. Critical thinking and problem-solving skills: Residency students need to be able to critically analyze problems, propose solutions, and contribute their insights to team discussions [5].

4.3. Application effects

The results of this study showed that the basic knowledge scores of the trainees in the observation group and the control group were 22.14 ± 2.32 and 21.33 ± 2.19, respectively, with no statistically significant difference ($P > 0.05$). The case analysis scores of the trainees in the observation group were 22.69 ± 2.75, the clinical skills scores were 35.66 ± 2.62, and the total score was 80.49 ± 7.69, all of which were significantly higher than 20.02 ± 2.45, 32.34 ± 2.78, and 73.69 ± 7.42 in the control group, with a significant difference ($P < 0.05$). The scores of the subjective feelings of the participants in the observation group during the learning process were learning efficiency (3.72 ± 1.13), clinical thinking (4.17 ± 0.69), communication (3.96 ± 0.82), faculty-student collegiality (3.89 ± 0.79), teamwork (3.65 ± 1.24), self-study (3.95 ± 1.18), classroom atmosphere (3.97 ± 0.97) points, self-directed learning (3.45 ± 1.42) points, and clinical thinking (4.07 ± 0.39) points; and in the control group, respectively, learning efficiency (3.04 ± 0.78) points, clinical thinking (3.79 ± 0.81) points, communication (3.24 ± 0.76) points, teacher-student collegiality (3.25 ± 0.64) points, teamwork (2.79 ± 1.31) points, self-learning ability (3.08 ± 1.38) points, classroom atmosphere (3.27 ± 0.85) points, independent learning (2.79 ± 1.05) points, and clinical thinking (2.79 ± 1.05) points. The observation group corresponded to higher than the control group, respectively, and the difference was statistically significant ($P < 0.05$). The results of the questionnaire survey suggested that the total satisfaction rate of teaching in the observation group was 96.87%, which was significantly higher than 75.75% in the control group ($P < 0.05$).

This is because, in the standardized training of gastroenterology residents, the application of PBL combined

with the flipped classroom teaching method can significantly improve trainees' clinical thinking ability, diagnostic and therapeutic skills, and self-learning ability. Through the discussion and analysis of actual cases, residents can better understand complex gastroenterology diseases and improve their ability to solve actual clinical problems [6]. In addition, this teaching mode can also enhance residents' teamwork and communication skills, laying a solid foundation for their future career development.

In conclusion, PBL combined with the flipped classroom teaching method provides an innovative and effective teaching model for the standardized training of gastroenterology residents by improving teaching efficiency and quality, which is worth being widely applied in clinical teaching.

Disclosure statement

The authors declare no conflict of interest.

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