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Research on the Application of PBL + SPOC Blended Teaching Model in Probability and Statistics Course

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Abstract: To cultivate talents with an exploratory spirit and practical skills in the era of information technology, it is imperative to reform teaching methods and approaches. In the teaching process of the Probability and Statistics course, an application-oriented blended teaching model combining problem-based learning and small private online course was explored. By organizing and implementing online and offline teaching activities based on problem-based learning, a multidimensional process-oriented learning assessment system was established. Practice has shown that this model can effectively enhance classroom teaching effectiveness, benefiting the improvement of students' overall skills and mathematical literacy.

Keywords: Problem-based learning teaching method; Blended learning; Probability and Statistics

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1. Introduction

The concept of "double first-class" clearly defines the goals and tasks of higher education development in China, emphasizing the core position of talent cultivation [1]. Enhancing the quality of talent cultivation relies on the reform of teaching methods and approaches, necessitating continuous exploration of educational reform methods and pathways. This includes optimizing teaching content, focusing on improving teaching quality, monitoring student learning outcomes, enhancing practical skills development, strengthening the integration of research and education, and ensuring that the latest research findings are promptly incorporated into teaching materials to stimulate students' interest in professional learning [2]. This approach aims to enable higher education to better adapt to and lead the demands of societal development, fostering a greater number of innovative and practically skilled individuals. "Probability and Statistics" is a fundamental discipline in modern science and engineering, emphasizing the development of students' thinking patterns and problem-solving skills. It encourages students to consider problems from multiple perspectives and make rational inferences and judgments, which are crucial for their future career development and lifelong learning.

Built upon the problem-based learning (PBL) teaching model, which uses problems as the starting point and core of learning, students are encouraged to apply mathematical thinking and interdisciplinary knowledge and skills to solve problems. Many studies have shown that the PBL teaching model has yielded positive results in practice

and gained widespread attention from educators [3-7]. However, PBL is mostly used in fields such as medicine, engineering, and social sciences, with limited research on its application in the course of Probability and Statistics. In practice, due to factors such as the nature of the course, class hours, and differences in student learning abilities, the exclusive use of the PBL teaching model by teachers still faces various challenges and may not achieve the expected teaching outcomes. In order to deeply integrate information technology with educational teaching, combining the PBL teaching model with small private online course (SPOC) online learning can revolutionize classroom teaching structures. By extensively applying mathematical thinking to interdisciplinary expansion and leveraging a blended teaching model, classroom teaching efficiency can be significantly improved [8,9]. This approach enhances student engagement and motivation, ultimately achieving the teaching goal of cultivating higher-order thinking skills.

2. The conceptual design of the blended teaching model combining PBL and SPOC

To address the limitations that may arise from solely using the PBL teaching method and align with the national initiative of deeply integrating information technology with educational teaching, the combination of PBL teaching with blended online and offline learning, facilitated by the rapid development of modern internet technologies, is more in line with the country's goal and requirements.

The online-offline hybrid teaching model of PBL + SPOC is primarily based on two core components: student learning of foundational knowledge and cultivation of students' comprehensive application abilities. In the first component, the phase of foundational knowledge learning, teachers guide students to engage in effective independent learning through SPOC before class by planning the overall teaching, thus laying a solid disciplinary foundation for students to apply foundational knowledge to solve real-world problems. The second component mainly focuses on classroom sessions, with teachers centering on students, not only requiring them to flexibly apply acquired knowledge but also to possess good habits of thinking such as analysis, judgment, innovation, and comprehensive application abilities. These two components are interwoven. Teachers also encourage students to engage in additional reading to broaden their learning horizons, utilize the learning platform to track and understand student progress throughout the teaching process, and maintain close communication with students. In short, the hybrid learning model of PBL + SPOC effectively integrates knowledge acquisition and skill development. The specific approach of PBL hybrid teaching is illustrated in **Figure 1**.

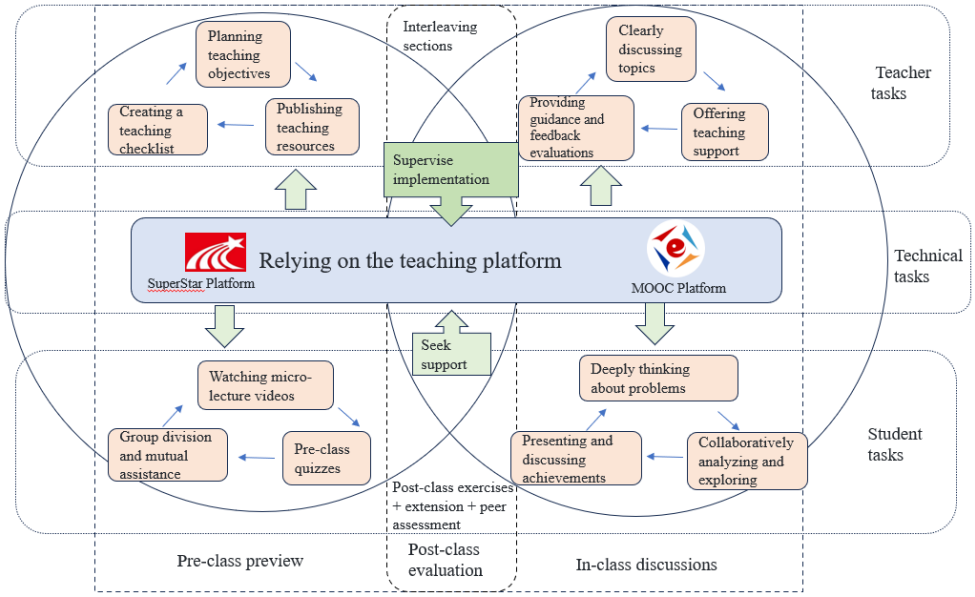

Figure 1. The design of the blended teaching model of PBL and SPOC

3. Implementation methods of the PBL + SPOC blended teaching model

3.1. Introducing teaching cases through SPOC before class

To facilitate effective group cooperation, students are required to form course study groups based on their dormitory assignments before the course begins. Before class, the teacher will post relevant materials, articles, and videos related to the case discussion on the learning platform, allowing students to read these materials in advance and understand the background of the case to be discussed. Next, the teacher will list the task list, set learning objectives and a study plan, guide students to preliminarily understand the chapter content through reading textbooks and lecture notes, and watch micro-lecture videos to preview new knowledge. Students can engage in learning exchanges and develop personal and group study plans through the online learning platform, completing knowledge quizzes to assess the effectiveness of their preview. Teachers can assess students' learning preparation by evaluating the statistics in the learning platform's backend, subsequently adjusting classroom teaching arrangements accordingly. The completion of pre-class tasks by students can also be considered as part of their routine assessment grades. In summary, through these activities, students can engage in goal-oriented independent learning, laying a solid foundation for the subsequent implementation of PBL teaching in offline settings.

3.2. Conducting PBL problem discussions during class

3.2.1. Clarifying teaching objectives and question design

Teachers assess students' pre-class preparation effectiveness through continuous questioning. By integrating the content of probability and statistics, and considering students' cognitive levels and knowledge structures, teachers can design questions that cover the core concepts and principles of the course. The aim is to further enhance the hierarchical nature of teaching objectives, enabling students to deepen their understanding of knowledge, grasp important mathematical skills, etc. Question design should be open-ended, encouraging students to think and explore from different perspectives.

3.2.2. Creating scenarios and introducing problems

Teachers create problem scenarios related to the course content through practical cases, real-life examples, or scientific experiments to stimulate students' desire for exploration. Through exploring these cases, teaching problems naturally arise, allowing students to perceive the authenticity and importance of the problems. Teachers guide students to analyze the purpose, requirements, and constraints of the problems, effectively training students in problem analysis and solving.

3.2.3. Conducting collaborative inquiry and results presentation

Once students have identified the case problems, they engage in discussions, analysis, and inquiry within their respective groups. Students are encouraged to propose hypotheses and verify them. While teachers can provide necessary guidance and support during this process, they should refrain from directly providing answers. Subsequently, group representatives present their inquiry results to the class, including problem-solving methods, conclusions, reflections, etc. Other students in the class are encouraged to discuss and exchange views on the group presentations, raising different viewpoints and questions. Throughout this process, teachers provide feedback and summaries on student contributions, highlighting strengths and areas for improvement. Based on students' learning situations and feedback, teachers design relevant extension tasks or projects to further stimulate students' interest in learning.

3.3. Carrying out knowledge summarization and expansion after class

After class, the teacher uses an online question bank to publish quiz questions and topics related to the lesson for

discussion. Students, upon completing assignments on time, actively participate in online topic discussions, which are recorded as part of their regular assessment on the learning platform. In the extracurricular extension segment, supplementary learning materials related to the course content are provided for students to ponder. For instance, in the comprehensive application of digital features, students are encouraged to further explore practical issues such as pricing mechanism analysis for finished products, broadening their perspectives, strengthening the link between theory and practical problems, and enhancing the applicability and innovativeness of the course.

4. Design of a multidimensional assessment and evaluation scheme for PBL + SPOC blended teaching

The evaluation system of the PBL + SPOC blended learning process should follow a student-centered approach, promote students' autonomy in learning, enhance their mathematical literacy, focus on the development of their individuality and multiple intelligences, and guide them to achieve learning goals through diversified evaluation. Therefore, in the construction of the evaluation system, assessment and evaluation should be conducted on four interrelated learning activities: the level of engagement in the learning process, classroom performance, contribution to group learning, and creativity in the learning process.

Firstly, the level of engagement in the learning process is mainly measured by the extent of students' motivation, study time, and intensity. Specific indicators include completing pre-class assignments as required, actively participating in class discussions and answering questions, engaging in online and offline interactions with teachers and peers, actively participating in group discussions, diligently completing homework, reviewing and reinforcing learning, and practicing exercises. These learning processes can be tracked and assessed through the learning platform. Secondly, classroom performance refers to the quality of completing various classroom learning tasks, such as demonstrating clear problem-solving processes, articulating thoughts and opinions coherently, applying learned knowledge effectively to practical situations, and mastering problem-solving methods. This aspect is primarily evaluated through classroom assessments. Next, group contribution measures the impact of an individual's learning activities on others' learning, such as collaborating with peers, taking on important roles in group tasks, and engaging in effective communication and cooperation within the group. Lastly, learning creativity refers to possessing innovative thinking and mathematical literacy, expanding and enhancing classroom discussions through extensive reading, online resources, self-study, etc., expressing unique ideas and questions, demonstrating independent thinking, and having the ability to solve problems using different methods. After establishing evaluation elements and criteria, the weighting coefficients of the procedural evaluation index system were determined through methods such as literature analysis, expert consultation, and comparative analysis (**Figure 2**).

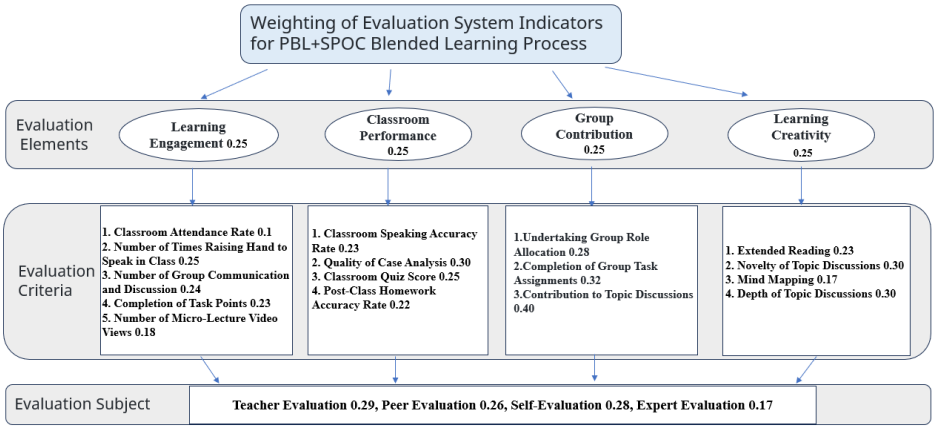

Figure 2. PBL + SPOC blended learning process evaluation system and weightings

5. Analysis of teaching effectiveness

In order to verify whether the blended learning model of PBL + SPOC is conducive to the improvement of students' comprehensive abilities, a survey on students' recognition of comprehensive abilities and qualities was conducted among 93 students in this class. The survey results show that students believe that their abilities have improved to varying degrees in the six aspects shown in **Table 1**; 85% of the students believe that their independent learning abilities have significantly improved, followed by varying degrees of improvement in problem-solving skills and team collaboration. The class's average final grade is 13.8 points higher compared to the control class in the same grade, indicating that this teaching model enables students to more flexibly grasp the knowledge and principles in the Probability and Statistics course. Therefore, the application-oriented blended teaching model of PBL + SPOC can effectively cultivate and enhance students' learning abilities and mathematical literacy.

Table 1. Survey results on students' comprehensive abilities

Communication skills	Independent learning	Team collaboration	Critical thinking	Problem-solving	Social responsibility
70.8%	85.6%	75.5%	35.2%	72.6%	26.5%

6. Conclusion

Problem-based learning emphasizes project-based learning, encouraging active exploration and collaboration, thereby fostering higher-order thinking and the ability to solve real-world problems. On the other hand, blended learning utilizes both online and offline resources, providing students with more flexible and diverse learning pathways. The hybrid teaching model proposed in this article, PBL + SPOC, not only leverages the strengths of each approach but also generates synergistic effects. With support from the online platform, students can access learning resources anytime and anywhere, engaging in self-directed learning and effectively addressing the constraint of limited classroom teaching time. Meanwhile, face-to-face teaching centered around project-based problems offers students opportunities for in-depth discussion and practical exploration, enhancing their performance in problem analysis and solving. A diversified formative assessment system serves the functions of guidance, regulation, and supervision, enhancing teaching evaluation, ensuring better learning quality for students, and promoting the improvement of talent cultivation quality. Designing targeted PBL tasks in the teaching practice requires teachers to invest more time and effort. Further exploration is needed to enhance efficiency in the teaching and learning process.

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Disclosure statement

The author declares no conflict of interest.

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