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Research and Practice of the Blended Teaching Model of BOPPPS Teaching Method Under the Background of Digital Education: Taking Operations Research Course as an Example

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Abstract: The rapid development of digital education provides new opportunities and challenges for teaching model innovation. This study aims to explore the application of the BOPPPS (Bridge-in, Objective, Pre-assessment, Participatory learning, Post-assessment, Summary) teaching method in the development of a blended teaching model for the Operations Research course under the background of digital education. In response to the characteristics of the course and the needs of the student group, the teaching design is reconstructed with a student-centered approach, increasing practical teaching links, improving the assessment and evaluation system, and effectively implementing it in conjunction with digital educational technology. This teaching model has shown significant effectiveness in the context of digital education, providing valuable experience and insights for the innovation of the Operations Research course.

Keywords: Digital education; BOPPPS teaching method; Blended teaching model; Operations research

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1. The development and integration of digital education

The world is undergoing a significant transformation unprecedented in a century, with a new round of technological revolution reshaping the socioeconomic structure, and the digital economy is becoming the dominant economy. Education is about cultivating people for the future and has a symbiotic relationship with the economy. The continuous development of the digital economy poses new requirements for talent cultivation, and the comprehensive digital transformation of education has become an inevitable trend [1]. At the 2024 World Digital Education Conference, Chinese Minister of Education Huaijin Peng proposed that digital education should evolve from the "3Cs"—Connection, Content, Cooperation—to the "3Is"—Integrated, Intelligent, International, adhering to Application and Governance to form the "GAI3" concept of digital education development [2]. Faced with the opportunities and challenges in the process of digital education development,

higher education needs to actively adapt and seek changes, build a digital education ecosystem, and form a new normal of human-machine collaborative education. The blend of online and offline teaching is an inevitable trend and requirement of current teaching reform. Digital technology can make the teaching practice process smarter, but in the digital age, teachers not only need to master the application of intelligent tools but also need to explore how to design top-level teaching and redesign the teaching model under the new educational ecology.

2. Analysis of the BOPPPS teaching model

The BOPPPS teaching model is based on constructivism, oriented towards educational objectives, and emphasizes a student-centered approach, playing an important role in the implementation of teaching in colleges and universities in the digital education era [3]. Constructivism emphasizes that learners learn new knowledge through active exploration, discovery, and construction, advocating for the guidance of students to participate, cooperate, inquire, and practice to promote their deep understanding and meaning construction. BOPPPS applies this theory to teaching, breaking down teaching activities into six processes: establishing the connection between old and new knowledge (Bridge-in), clarifying the teaching objectives (Objective), pre-assessing the teaching content (Pre-assessment), participatory learning (Participatory learning), post-assessing at the end of the teaching (Post-assessment), and finally summarizing the knowledge points (Summary). The BOPPPS teaching model focuses more on what students have "learned" rather than what the teacher has "taught." In the context of digital education, this teaching model not only allows students to achieve participatory learning through online education but also provides timely feedback for teachers, facilitating the adjustment of teaching pace and meeting the personalized learning needs of students.

3. Analysis of the current status of Operations Research courses

Operations Research originated in the late 1930s and is an interdisciplinary applied science that emphasizes a quantitative basis, applying scientific and mathematical methods to solve practical problems. As a core course for majors in management science and engineering, it aims to cultivate students' ability to apply mathematical principles and methods to solve practical problems, especially to establish an optimal thinking model, and provide a scientific basis for management decisions under conditions of limited resources or multiple objectives. The implementation steps of Operations Research generally include analyzing practical problems, establishing mathematical models, and solving optimal plans. Currently, there are several issues in the specific teaching process:

(1) The teaching content focuses more on calculation and less on modeling, emphasizing the derivation of mathematical formulas, lacking in actual problem analysis, focusing on the "model solving" part, and neglecting the inspiring parts of "problem discovery" and "result verification." There is a lack of cultivation of students' thinking abilities, leading to insufficient application capabilities.

(2) The course teaching is mainly teacher-centered, with traditional and single teaching methods, where students passively receive knowledge, the learning process lacks interest, and if they fail to keep up with the teacher's pace in time, it may lead to knowledge omissions, limiting students' subjective initiative and affecting their learning enthusiasm.

(3) The course assessment and evaluation criteria are single, mainly based on the final exam scores, and the process assessment is also limited to homework scores and attendance. This approach focuses on the assessment of results rather than a comprehensive evaluation of the entire learning process of students. The course evaluation system lacks timeliness, feedback, and effectiveness.

(4) The teaching links lack practicality, mainly relying on students' manual calculations, and lack the ability to use optimization software such as Excel and MATLAB for problem-solving. Although manual calculations help understand the principles of Operations Research, in the digital age, students need to master the ability to use tools for model processing and analysis.

In light of the aforementioned issues in the teaching process of Operations Research, many research scholars have proposed ideas and methods for curriculum reform. Liu believed that the construction of a blended online and offline teaching model for Operations Research in applied undergraduate colleges can integrate pre-class, in-class, and post-class links, fully integrating various teaching elements [4]. Based on the blended model, Huang *et al.* carried out the ideological and political practice of Operations Research courses and, according to practical feedback, the blended teaching can expand the teaching time and space, and improve the teaching effect [5]. Under the blended teaching model, Zhang used cases and Operations Research software for teaching content expansion, improving students' comprehensive application ability [6]. Based on the OBE concept, Zhao *et al.* constructed the "teaching" and "learning" of Operations Research, highlighting goal orientation, student-centeredness, and continuous improvement [7]. Based on the problem-based learning (PBL) teaching method, Bai *et al.* carried out the teaching of Operations Research experimental courses, improving students' learning interest [8].

Although many research scholars have proposed methods to improve students' interest and learning effectiveness, there is still a lack of comprehensive control and evaluation of the entire teaching process of students, especially under the background of digital education, how to integrate online education and digital technology, connect all links of the learning chain, and establish an objective and comprehensive course evaluation system is still an important and complex issue. Under the background of "Internet+," the role of the BOPPPS teaching model is highlighted, not only because the teaching objectives are clearly set and verifiable, the teaching methods emphasize the participation of both teachers and students, but also by combining blended teaching and using information technology platforms, it can better promote the cultivation of students' independent learning and practical skills, while achieving a scientific and comprehensive course evaluation and assessment.

4. Implementation of Operations Research blended teaching based on the BOPPPS teaching model

Most applied undergraduate colleges have 48–64 class hours for Operations Research courses, mainly theoretical, covering topics such as linear programming problems, duality problems, transportation problems, goal programming, integer programming, dynamic programming, graphs and networks, and inventory theory. In response to the problems existing in traditional teaching, an attempt is made to carry out the blended teaching of Operations Research based on the BOPPPS teaching model using digital technology.

4.1. Phase one: Bridge-in

The bridge-in phase is an important link in the teaching model and serves as a bridge for teaching activities. The purpose is to guide students to establish connections with new knowledge from their existing knowledge and experience, helping them smoothly transition to the content they are about to learn. In this phase, teachers can release preview video materials and learning materials on the online platform before class, allowing students to have a preliminary understanding of the relevant background knowledge and concepts, laying the foundation for the smooth progress of learning. The video materials should be as concise as possible, and the selected cases should be able to provoke students' thinking and interest, thereby stimulating their desire for independent learning.

4.2. Phase two: Objective

Centering on the teaching objectives of all-round education, a trinity of knowledge, skill, and quality is constructed to form a complete and organic teaching organization. Knowledge, as the cornerstone of teaching, aims to cultivate students' mastery of the basic theory of Operations Research, mathematical modeling, and solution methods. Skill, as an extension of knowledge, focuses on training students' logical thinking, guiding them to actively discover problems, establish models, and use optimization tools and software to solve Operations Research problems, enhancing their ability to analyze and solve practical problems. Quality is the manifestation of skill, emphasizing the cultivation of students' innovative thinking, team cooperation, communication skills, and other comprehensive qualities. Teachers can release learning task sheets on the online platform before class, clarifying the key knowledge and learning objectives of video learning, and helping students to learn independently and efficiently.

4.3. Phase three: Pre-assessment

Under the blended learning model, the practice of pre-assessment has undergone significant changes. Traditionally, pre-assessment is conducted by teachers before the commencement of teaching activities to gauge the students' foundational knowledge level. However, in a blended learning environment, the sequence of knowledge impartation and internalization is altered by the students' autonomous learning. Self-assessment is facilitated through online testing tasks, which help students understand their starting point and stimulate their motivation to learn. Teachers provide effective guidance and supervision of students' online learning before class, gaining a comprehensive grasp of the completion status of autonomous learning based on students' online learning behavior data, assessing the overall learning level of the class, and identifying the key and difficult points for offline classroom instruction. The pre-assessment includes both objective and subjective questions, which not only examine students' level of knowledge acquisition but also document learning inquiries to encourage students to delve deeper into their thinking.

4.4. Phase four: Participatory learning

The phase of participatory learning is conducted through face-to-face teaching activities to enhance students' engagement, inquiry, and practical application, thereby fostering a deep understanding and meaningful construction of knowledge. Teaching in this phase addresses issues reflected from the pre-assessment stage and focuses on the key and challenging aspects of the knowledge. It employs heuristic and inquiry-based teaching methods to guide students in building a comprehensive theoretical knowledge system. Additionally, it utilizes case study analysis, experimental teaching methods, situational teaching, and group discussions to inspire students to connect theory with practice. This approach encourages students to propose optimization plans based on decision-making scenarios and explore the use of optimization software such as Excel and MATLAB to solve modeling problems, thereby cultivating their teamwork and problem-solving skills. Common issues in this phase include a lack of initiative among students leading to low participation, and disagreements or communication barriers during group cooperation. If these issues are not properly addressed, offline classroom activities may devolve into a one-sided presentation by the teacher.

Leveraging digital technology to create a smart classroom can effectively resolve these issues. Teachers can use the online platform to post interactive features such as selection processes, quick-response quizzes, voting, thematic discussions, and group chats, which stimulate student interest and increase engagement. It is particularly important to establish an incentive mechanism where students earn points for participating in classroom activities, creating a more interactive and effective learning environment. Moreover, the smart classroom can record the teaching process and generate detailed classroom reports, including the activities

posted by the teacher and students' participation, which can be used to enhance teaching quality.

4.5. Phase five: Post-assessment

The post-assessment phase is not only about testing whether students have achieved their learning objectives for a particular stage but, more importantly, it involves a deep extension of knowledge with an emphasis on applicability and higher-order thinking. Typically, the degree to which learning objectives are met can be assessed through classroom evaluations. However, the aspects of applicability and higher-order thinking are often overlooked. It is precisely against the backdrop of digital education that universities, in collaboration with businesses via the Internet, can jointly establish simulation system platforms and host national competitions. This approach promotes teaching and learning through competition, achieving advanced learning. The competitions use computer technology to simulate the competitive environment of real businesses, where students apply knowledge of production management, financial accounting, and other management disciplines, as well as quantitative analysis methods such as statistics and operations research, to achieve strategic business objectives. This process cultivates students' ability to correctly use decision analysis tools for management quantitative analysis and scientific decision-making. It also tests their grasp of optimization theories and analytical methods in operations research, strengthens their ability to integrate and construct knowledge, and fosters team spirit in group competitions, laying a foundation for their future professional development.

4.6. Phase six: Summary

The summary phase plays a crucial role in the teaching process. It is not only an opportunity for teachers to systematically review and summarize the course content but also a key step in promoting students' deepened understanding of knowledge and consolidation of memory. During the summary process, teachers can help students organize the knowledge they have learned by refining key concepts and critical information. They can also pose open-ended questions to stimulate students' thinking and discussion, thereby expanding the depth and breadth of their knowledge. Furthermore, guiding students to self-summarize and integrate helps them consolidate scattered points of knowledge into a systematic knowledge structure. It is important to note that the summary phase also includes the important aspect of teaching evaluation and feedback. Teaching evaluation involves not only the teacher's assessment of students but also the students' evaluation of the teacher. When evaluating students, teachers can combine formative and summative assessments, conducting a comprehensive evaluation from multiple dimensions such as the degree of knowledge acquisition, learning attitude and behavior, and classroom participation and performance. This ensures the objectivity, fairness, and comprehensiveness of the evaluation. The formative evaluation covers various aspects, including online video learning, chapter quizzes, classroom points, homework, and competitions. With the support of digital technology, student evaluation becomes more quantifiable, traceable, and visual, helping students to have a clearer understanding of their learning status and stimulating their motivation to learn. For students' evaluation of teachers, it is necessary to follow the principles of anonymity, objectivity, and multidimensionality. This can be achieved through various forms such as online anonymous voting and cross-disciplinary student interviews, encouraging students to actively participate in the evaluation process and fully express their views and suggestions on teaching content and methods. A comprehensive and multidimensional evaluation helps to gather richer and more authentic feedback, which in turn promotes the teacher's teaching improvement and professional growth. This reciprocal evaluation mechanism between teachers and students, which promotes mutual improvement, is of great significance for promoting the continuous improvement and optimization of classroom teaching.

5. Conclusion

This paper, set against the backdrop of digital education, has explored the research and implementation of the BOPPPS teaching method and blended learning model, in conjunction with the specialized, applied, and practical characteristics of the Operations Research curriculum. It has focused on student-centered educational objectives, advocating for the integration of online and offline teaching to expand the dimensions of learning and facilitate the transition from traditional classroom instruction to a blended learning approach suitable for the digital era. In terms of educational assessment, the study calls for an expansion in the scope of process-oriented evaluations and the introduction of a two-way feedback mechanism between teachers and students, which provides timely feedback on learning outcomes and informs continuous improvements in teaching methodologies. There is a particular emphasis on the practical aspects of teaching, with encouragement for students to participate in simulated competitions to enhance their applied skills. In summary, this research offers innovative perspectives and methodologies for the reform and advancement of Operations Research courses.

Disclosure statement

The author declares no conflict of interest.

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