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Research and Application of Blended Teaching for Principles of Operating Systems Enabled by Artificial Intelligence

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Abstract: Aiming at the problems of strong abstractness, high practical difficulty, and insufficient personalization in traditional blended teaching of the Principles of Operating Systems course, this paper deeply integrates artificial intelligence technology with blended teaching and constructs an AI-enabled blended teaching model for the operating systems course. Taking the AI support layer, teaching implementation layer, and evaluation feedback layer as the framework, this model designs an intelligent teaching process centered on pre-class, in-class, after-class, and practical teaching links, and establishes a diversified and integrated teaching evaluation system. A controlled teaching experiment was conducted in parallel classes of computer majors in a university, and the teaching effect was analyzed via score comparison, questionnaire surveys, and interviews. The results show that the model can effectively improve students' learning interest and course performance, enhance their practical operation ability, and reduce teachers' teaching burden, which can provide a reference for the teaching reform of core computer courses.

Keywords: Artificial intelligence; Blended teaching; Principles of Operating Systems; Personalized learning; Teaching evaluation

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1. Introduction

The rapid iteration and practical application of artificial intelligence (AI) technology have promoted the widespread popularization of AI educational products such as intelligent teaching platforms, personalized learning systems, and virtual simulation tools, profoundly reforming the teaching mode of higher education [1,2]. As a new teaching mode integrating the advantages of online autonomous learning and offline interactive teaching, blended teaching has become the mainstream direction of curriculum reform in colleges and universities. By integrating online and offline teaching resources, it effectively compensates for the limitations of traditional teaching and improves the flexibility and pertinence of teaching [3,4]. Principles of Operating Systems is a core fundamental course for computer-related majors, covering abstract knowledge points including process management, memory management, device management, and file management. It is characterized by a strong theoretical nature, rigorous logic, and high practical thresholds [5,6]. Under the traditional teaching mode, the course generally suffers from pain points such as difficulties in students' understanding, weak practical operation ability, and difficulty in accommodating individual learning differences [7,8]. Against this background, the deep integration of AI technology and blended teaching—relying on AI's core functions including intelligent analysis, personalized recommendation, and virtual simulation—to accurately solve curriculum teaching problems and realize the innovative upgrading of teaching modes has become an inevitable choice to promote the high-quality development of the Principles of Operating Systems course. It also provides a new idea and practical path for the teaching reform of computer-related professional courses [3,4,9].

1.1. Research significance

This study has both theoretical and practical value, which complement each other. It not only enriches the research achievements in the field, but also provides implementable reference schemes for actual teaching.

In terms of theoretical significance, this study focuses on the deep integration of AI technology and blended teaching of Principles of Operating Systems, deeply explores the internal logic and implementation paths of their combination, enriches the research system of the integration of artificial intelligence and computer professional courses, further improves the application theory of blended teaching in science and engineering courses, and provides a new theoretical perspective for the teaching research of similar professional courses.

In terms of practical significance, the AI-enabled blended teaching model constructed in this study can effectively solve the teaching pain points of the Principles of Operating Systems course. Through AI technology, it realizes accurate analysis of learning status, personalized teaching recommendation, and intelligent guidance of practical process, so as to improve students' learning interest and participation, strengthen their theoretical comprehension and practical operation abilities, and comprehensively improve the quality of course teaching. At the same time, this model can provide replicable and popularizable practical experience for the curriculum reform of computer majors in colleges and universities, and help cultivate high-quality computer professionals who meet the needs of the artificial intelligence era.

1.2. Research status at home and abroad

Foreign research on the application of AI in higher education and operating systems courses started early and has formed a mature application system. Universities in developed European and American countries generally introduce intelligent teaching platforms, use machine learning techniques to analyze students' learning data, and realize personalized learning resource recommendation and accurate evaluation of learning effects. Some universities have also developed AI-based virtual simulation experiment systems to help students intuitively understand abstract concepts and lower the threshold of practice [10–12]. For example, Stanford University in the United States has developed an intelligent Q&A system based on natural language processing technology, and the University of Cambridge in the United Kingdom combines AI virtual simulation technology with blended teaching to construct immersive practical teaching scenarios.

Relevant research in China has developed rapidly in recent years. Many universities have focused on the blended teaching reform of the Principles of Operating Systems. However, most studies still stay at the level of optimizing the traditional blended teaching mode. AI technology is only applied in shallow scenarios such as intelligent question banks and online Q&A, without deep integration with all links of teaching. The core advantages such as learning situation analysis, personalized teaching, and practical guidance have not been fully utilized. In addition, there is a lack of complete teaching modes and evaluation systems, and the verification of teaching effects is not comprehensive enough [5,6,8].

Based on the deficiencies of existing research, this study constructs an operable and targeted integration model, verifies its effectiveness through practice, and fills the gaps in current research.

1.3. Research content and methods

The core content of this study is divided into four parts: Firstly, sort out the theoretical basis of blended teaching and AI educational technology, and clarify the teaching characteristics and core pain points of the Principles of Operating Systems course. Secondly, construct an AI-enabled blended teaching model for Principles of Operating Systems, determine its construction principles and overall framework, design the implementation process of pre-class, in-class, after-class, and practical teaching links, and develop supporting teaching resources and evaluation systems. Thirdly, select pilot classes and control classes to carry out teaching practice, record the implementation process, and collect relevant data. Fourthly, verify the teaching effect by combining quantitative and qualitative analysis, summarize the existing problems of the model, and put forward optimization strategies.

This study adopts a variety of methods to ensure scientificity: the literature research method is used to sort out domestic and foreign research results and lay a theoretical foundation; the questionnaire survey method is adopted to collect data such as students' learning interest and recognition degree; the experimental method is applied to select parallel classes for comparative teaching; the interview method is used to obtain the application experience and improvement suggestions of teachers and students; and the data analysis method is utilized to sort out and analyze the data so as to verify the effectiveness of the model.

1.4. Research innovations and technical route

The main innovations of this study are as follows:

First, the precise integration of AI technology and curriculum teaching is realized. Aiming at the pain points of the course, such as abstract and difficult content, high practical threshold, and large individual differences among students, machine learning, virtual simulation, natural language processing, and other technologies are embedded into the whole teaching process, and a blended teaching model of "AI support–hierarchical teaching–accurate evaluation" is constructed.

Second, a diversified and integrated AI-enabled teaching evaluation system is constructed. Combining AI-based process evaluation, teachers' summative evaluation, and student self- and peer-evaluation, a comprehensive and accurate assessment of learning effects is achieved.

The technical route follows the logic of "theoretical foundation–model construction–practical implementation–effect verification–optimization and improvement", which is carried out in five stages: literature research and investigation analysis, teaching model construction, implementation preparation and resource development, comparative teaching and data collection, effect analysis and model optimization.

2. Relevant theories and technical foundations

2.1. Theories related to blended teaching

Blended teaching is a novel model that deeply integrates online autonomous learning and offline interactive teaching. Its core characteristics include online-offline collaboration, the combination of teacher-led instruction and student-centered learning, as well as the complementarity between personalized learning and collective teaching. Its main forms include flipped classroom, online-offline integration, and project-driven blended teaching, among which the flipped classroom model is suitable for the characteristics of Principles of Operating Systems as a course integrating both theory and practice [1,4,7].

Constructivist learning theory and personalized learning theory serve as the core support for blended teaching. Constructivism holds that learning is a process in which students actively construct knowledge, with teachers acting as guides. Personalized learning theory focuses on individual differences among students and advocates teaching students in accordance with their aptitude, which is highly consistent with the concept of blended teaching [1,4].

When applied to computer specialty courses, this model can break the constraints of time and space, balance theoretical and practical teaching, resolve difficulties in autonomous learning, and improve teaching quality [9].

2.2. AI education-related technologies and applications

The core technologies of AI in education include machine learning, natural language processing, virtual simulation, intelligent recommendation, and others. Machine learning can mine learning patterns and weak links, supporting personalized resource recommendation and learning effect evaluation. Natural language processing enables intelligent human-computer interaction and constructs an all-weather intelligent Q&A system. Virtual simulation converts abstract theories into intuitive operations, thus lowering the practical threshold. Intelligent recommendation delivers targeted resources based on students' learning data to realize personalized learning [2,3].

Applications of AI in education cover various scenarios including intelligent Q&A, personalized recommendation, process evaluation, virtual simulation practice, and teaching resource generation. The integration of AI and blended teaching presents four major advantages: accurate learning status analysis, diversified teaching scenarios, intelligent and multi-dimensional evaluation, and consideration of individual differences to implement teaching in accordance with students' aptitude [3,4,9].

2.3. Course analysis of Principles of Operating Systems

Principles of Operating Systems is a core fundamental course for majors such as Computer Science and Technology, Software Engineering, and Artificial Intelligence. Its teaching content includes process management, memory management, device management, file management, deadlock handling, etc. The teaching objective is to enable students to master the core principles and implementation methods of operating systems, cultivate their abilities in theoretical analysis and practical operation, and lay a foundation for subsequent professional courses [5,6].

The course has prominent key and difficult points: core principles and implementation mechanisms are the teaching emphasis, while abstractness and logicality are the main difficulties in understanding. In addition, the course has high practical requirements, making it rather challenging for students to learn [5,8].

Current teaching modes are divided into traditional teaching and single blended teaching. The traditional mode is dominated by teacher lecturing, in which students passively receive knowledge and lack practice and personalized guidance. The single blended mode only simply integrates online and offline resources without intelligent learning status analysis and personalized teaching, and is insufficient in offline interaction, thus failing to solve the core pain points of the course [6,7].

3. Construction of AI-enabled blended teaching model for Principles of Operating Systems

3.1. Principles for teaching model construction

The model construction follows four core principles:

First, student-centeredness. Based on learning needs and individual differences, AI is utilized to realize personalized teaching and stimulate students' learning initiative.

Second, deep integration of AI and the curriculum. Formalistic application of technology is avoided; AI is embedded into the whole teaching process to address the key and difficult points of the course as well as students' learning pain points.

Third, integration of theory and practice. AI virtual simulation is relied on to strengthen practical teaching, connecting theoretical knowledge with practical operational abilities.

Fourth, operability and extensibility. The model conforms to the actual teaching situation in colleges and universities, adapts to teachers' AI application capabilities and resource conditions, and can be iteratively optimized with the development of technology and teaching demands.

3.2. Overall framework design of the teaching model

The overall framework of the model is divided into three layers, which support each other to form a complete teaching system (**Figure 1**).

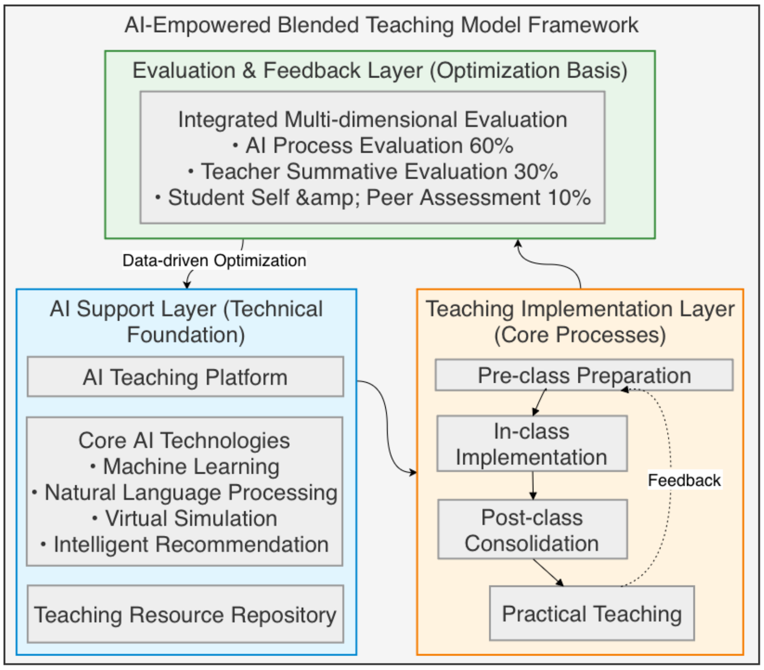

Figure 1. AI-empowered blended teaching model framework.

The AI support layer serves as the technical foundation, including the AI teaching platform, core AI technologies, and teaching resource repository, providing technical support such as learning status analysis and personalized resource recommendation.

The blended teaching implementation layer is the core link, covering four stages: pre-class, in-class, after-class, and practical teaching, forming a closed-loop teaching process.

The evaluation and feedback layer acts as the basis for optimization, collecting data through multiple evaluations to achieve continuous improvement of teaching quality.

3.3. Design of AI-based blended teaching links

Pre-class preparation stage: The AI platform analyzes students' previous learning data through machine learning, recommends personalized preview resources, and provides intelligent Q&A to resolve preview questions in a timely manner, helping students consolidate prerequisite knowledge and identify knowledge gaps.

In-class implementation stage: Teachers use AI virtual simulation to demonstrate abstract knowledge points. The AI collects classroom interaction data in real time, based on which teachers adjust the teaching pace, focus on explaining common problems, and provide individualized guidance for specific difficulties.

After-class consolidation stage: The AI recommends personalized assignments and review materials according to students' in-class performance, automatically grades assignments and generates feedback reports, and provides all-weather intelligent Q&A to help students consolidate knowledge.

Practical teaching stage: The AI virtual simulation platform simulates practical scenarios such as process scheduling and memory management, guides operations in real time, corrects errors, and records experimental data to provide a basis for teaching evaluation.

The detailed teaching flow chart is shown in **Figure 2**.

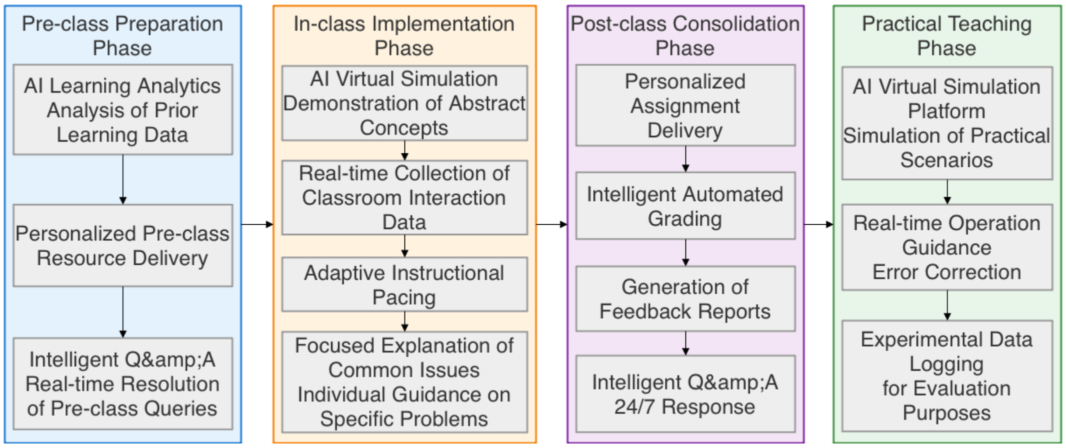

Figure 2. Detailed teaching flow chart

3.4. AI-enabled teaching resource construction

Teaching resource construction focuses on three core types of content: Generative AI is used to produce courseware and micro-lectures tailored to key and difficult teaching points, visualizing abstract knowledge. A hierarchical and classified intelligent question bank is built, with AI accurately pushing exercises and updating them in real time according to students' learning status. Virtual simulation scenarios covering core practical contents are developed to reduce hardware dependence and meet diverse practical needs.

3.5. Design of the teaching evaluation system

A diversified and integrated evaluation method is adopted, with the weight distribution as follows: 60% for

AI-based process evaluation, 30% for teachers' summative evaluation, and 10% for students' self- and peer-assessment. AI-based process evaluation collects full-process learning data in real time to comprehensively assess learning attitude and progress. Teachers' summative evaluation examines theoretical application and practical abilities through course examinations and curriculum designs. Students' self- and peer-assessment guide self-reflection and experience exchange, improving autonomous learning and cooperative abilities. This system achieves a comprehensive and objective evaluation of learning effects and makes up for the one-sidedness of single evaluation methods.

4. Application and implementation of AI-enabled blended teaching

4.1. Implementation preparation

Two parallel classes of Grade 2024 computer majors in a university are selected as experimental subjects. There are 45 students in the experimental class, who receive AI-enabled blended teaching, and 44 students in the control class, who adopt traditional blended teaching. There is no significant difference in learning foundation between the two classes. A teaching platform integrating multiple AI technologies is constructed, with supporting software and hardware equipment to guarantee online learning and virtual practice. Training on the operation and application of the AI platform is conducted for teachers to improve their technical application ability. Comprehensive debugging is carried out on courseware, question banks, and virtual simulation resources, and the personalized recommendation scheme is optimized.

4.2. Implementation process

The teaching period lasts 16 weeks. The experimental class implements the closed-loop process of pre-class–in-class–after-class–practice: 2 class hours of offline classroom teaching per week with interactive teaching supported by AI virtual simulation, and 1 class hour of offline practice per week with independent operation completed on the virtual simulation platform. AI provides personalized recommendations, intelligent grading, and real-time guidance throughout the whole process. The control class adopts the traditional mode of online resource recommendation plus offline lecturing without AI assistance. Teaching links are dynamically optimized according to feedback from teachers and students during implementation.

4.3. Implementation process recording and data collection

Data collection is divided into two categories: learning data are collected through the AI teaching platform and teaching management system, including quantitative data such as preview performance, classroom participation, assignments, experiments, and course scores; feedback data from teachers and students are obtained through mid-term and final questionnaires as well as final interviews, collecting qualitative information such as learning interest, model recognition, and teaching experience. All data are screened and verified to ensure authenticity and validity.

5. Analysis and verification of teaching application effect

5.1. Data processing methods

A combination of quantitative and qualitative analysis is adopted. For quantitative data, Excel and SPSS are used for statistical analysis and independent samples *t*-test to compare indicators such as academic performance and participation between the two classes. For qualitative data, coding analysis is applied to extract core viewpoints from teachers' and students' feedback, and summarize the advantages and problems of the model.

5.2. Comparative analysis of teaching effects

Data show that the teaching effect of the experimental class is significantly better than that of the control class. In terms of course scores, the experimental class has an average final score of 82.3, an excellent rate of 35.6%, and a pass rate of 97.8%, while the control class has 73.5, 18.2%, and 86.4% respectively, with statistically significant differences. In terms of learning participation, the experimental class has a preview completion rate of 95.6%, an average of 8.7 classroom interactions per student, and an assignment completion rate of 98.9%, all much higher than those of the control class. In terms of practical ability, the experimental class has an average experiment score of 84.5 and an operation standard score of 86.2, which are significantly higher than those of the control class. The results prove that the AI-enabled model effectively improves students' learning interest, academic performance, and practical ability.

5.3. Analysis of teacher and student feedback

Among student feedback, 88.9% agreed that the model stimulated learning interest, 86.7% believed it helped understand abstract knowledge, 84.4% approved of personalized recommendations, and 77.8% were satisfied with the model. Meanwhile, students suggested optimizing the response speed of intelligent Q&A, virtual simulation scenarios, and assignment difficulty.

From teacher feedback, AI-based learning status analysis and automatic grading reduced the teaching burden and improved teaching pertinence. Teachers also suggested enhancing their own AI application abilities and optimizing the platform's data statistics function.

Overall, the model has been widely recognized by teachers and students, with room for improvement only in technical application and resource adaptation.

5.4. Validity conclusion of the teaching model

The AI-enabled blended teaching model for Principles of Operating Systems can effectively solve the pain points in course teaching. Through full-process AI integration, it realizes precise teaching and personalized instruction, significantly improving students' learning effectiveness, practical ability, and comprehensive quality, while reducing teachers' teaching burden. It provides a feasible solution for the reform of this course and similar computer professional courses, and possesses good promotional value.

6. Conclusion and outlook

This study has completed the model construction, practical verification, and optimization design of the AI-enabled blended teaching for Principles of Operating Systems. The results show that this model effectively solves the pain points in course teaching, improves the teaching quality and the teaching experience of both teachers and students, and has dual theoretical and practical value.

The study has limitations such as a narrow research scope, a short experimental period, and insufficient depth of AI application. In the future, we will expand the research scope, extend the experimental period, deepen the integration of generative AI and course teaching, continuously optimize the teaching model, and promote it to similar computer professional courses, so as to provide more practical references for the reform of higher education teaching.

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Disclosure statement

The authors declare no conflict of interest.

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