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Application of AI-Enabled Teaching in the Course of Probability Theory and Mathematical Statistics

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Abstract: To address the shortcomings of traditional teaching methods in personalized support, real-time feedback, and comprehensive evaluation, this study proposes an AI-driven instructional model. The model provides students with personalized learning paths and structured resources through intelligent recommendation systems and knowledge graphs; optimizes the learning process by integrating blended learning to achieve a closed-loop system encompassing self-directed pre-class preparation, interactive in-class engagement, and targeted post-class reinforcement; and establishes a multidimensional evaluation system that combines formative assessment with competency-based evaluations of competition performance and practical skills, thereby fostering students' comprehensive development. The findings demonstrate that this model not only significantly enhances students' mastery of theoretically challenging courses such as Probability and Mathematical Statistics, but also improves learning initiative and practical application skills, offering a scalable intelligent solution for the reform of mathematics education in higher education institutions.

Keywords: AI-enabled teaching; Blended learning; Knowledge graph

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1. Introduction

With the advancement of educational informatization, the application of AI technology in teaching has become increasingly widespread [1–5]. Traditional teaching methods are unable to meet the personalized needs of every student, whereas AI, through intelligent recommendation systems and personalized learning path designs, can recommend suitable learning resources based on students' learning behaviors and progress in real time. AI also provides immediate feedback and suggestions, helping students grasp knowledge more efficiently. At the same time, AI-assisted teaching can optimize the teaching process, enhance teaching interactivity and classroom efficiency, and establish a diversified evaluation system, thereby comprehensively promoting the development of students' overall qualities. Probability theory and mathematical statistics are mathematical disciplines that study the objective laws of random phenomena and apply them in practice. They are fundamental courses in mathematics with a wide audience and high attention. In traditional teaching of probability theory and

mathematical statistics, due to the abstract nature of the subject and the complexity of its knowledge structure, students often struggle to internalize fundamental concepts such as probability distributions, expectations, and variances. The knowledge system is extensive and highly interconnected, and students often lack a clear understanding and intuitive recognition, which leads to confusion and frustration, making it difficult to establish a complete knowledge framework. Traditional teaching lacks personalized support, and students with different learning levels cannot receive targeted guidance. As a result, high-performing students may find the content too simple, while weaker students may struggle to keep up, which affects their practical application abilities.

2. AI-enabled teaching resource integration for promoting efficient learning

The use of AI to construct knowledge graphs to support teaching is becoming an important trend in the field of education, especially in knowledge management and personalized learning. For example, Qin et al. (2024) studied the method of constructing a knowledge graph using AI, taking database courses as an example [6]. Bai et al. (2024) studied the design and application of knowledge graphs in AI teaching platforms, focusing on semantic analysis-based teaching resource retrieval, and demonstrated its effectiveness through an experiment showing improved student scores [7]. A knowledge graph visualizes the relationships and hierarchical structure between different knowledge points through nodes and edges, helping students understand complex subject matter [8–10]. When constructing a knowledge graph, AI technologies such as Natural Language Processing (NLP), machine learning, and deep learning are used to automatically analyze vast amounts of teaching resources, textbooks, academic papers, and student feedback, thereby extracting connections between knowledge points and concepts to form a systematic knowledge network.

In teaching activities, specifically for the course "Probability Theory and Mathematical Statistics," AI can systematize and visualize scattered course content through the construction of a knowledge graph, thus improving learning efficiency. The knowledge graph uses core concepts from courses like probability theory and mathematical statistics (such as random events, distributions, expectations, etc.) as nodes, and dynamically links resources such as videos, question banks, and case analyses to corresponding knowledge points, forming a clear and structured network. Teachers can embed preset learning objectives into the graph, allowing students to quickly locate key content and understand the intrinsic relationships between knowledge points. At the same time, AI algorithms can analyze student learning behaviors and data to dynamically adjust the content of the graph, for example, recommending supplementary materials or extended learning paths based on the student's mastery level, thereby avoiding wasted learning resources.

On the other hand, the knowledge graph, combined with intelligent search functions, can help students quickly locate the resources they need through keyword searches, improving problem-solving efficiency. Through this resource integration, AI not only provides students with a panoramic learning framework but also offers teachers valuable teaching data feedback, optimizing teaching strategies and achieving efficient management and precise allocation of learning resources.

3. AI empowered blended learning model: Optimizing the learning process

Blended learning [11–16] is a model that combines traditional face-to-face teaching with online learning, consisting of three stages: pre-class flipped learning, in-class deepening learning, and post-class consolidation. Pre-class, teachers upload resources such as textbooks and videos on platforms like Chaoxing Learning Platform,

allowing students to learn independently and complete tasks. Teachers use statistical data to assess students' learning progress and plan teaching activities. In-class, teachers explain key points based on students' pre-class preparation, answer questions, organize interactive discussions, and design online assignments or projects. Through data analysis, teachers evaluate students' abilities and optimize teaching strategies. Post-class, teachers collect student feedback to improve teaching plans. This blended online-offline model provides the foundation for AI-assisted teaching, enabling precise support for each teaching phase and enhancing learning outcomes.

3.1. Pre-class flipped learning

Teachers upload teaching materials to the Chaoxing Learning Platform, and with the help of an AI recommendation system, personalized supplementary resources (such as short videos, case articles, and interactive exercises) are pushed to students based on their learning progress and behavioral data, helping them consolidate knowledge more efficiently. At the same time, teachers can use AI to generate targeted pre-study quizzes with automatic grading functionality, accurately recording students' common errors and weak areas. Additionally, teachers can post thought-provoking questions in the platform's discussion area, such as "How can the total probability formula be used to predict user preferences?" to guide students in interactive pre-study. With AI's real-time feedback functionality, teachers can comprehensively assess students' pre-class preparation, enabling them to adjust the classroom content precisely to ensure the teaching objectives align closely with students' needs. Through the collaborative support of the Chaoxing Learning Platform and AI technology, teachers can not only implement an efficient flipped classroom pre-study model but also help students master core concepts solidly, laying a strong foundation for subsequent classroom discussions and case analyses.

3.2. In-class deepening learning

Taking conditional probability and the total probability formula as examples, in the in-class deepening phase, teachers can set practical real-life scenarios (such as "recommending the most interesting movie categories based on a user's viewing history") to help students intuitively understand the specific application of conditional probability and the total probability formula in recommendation systems. With AI-powered intelligent grouping, teachers can form complementary learning groups based on students' pre-class preparation performance, allowing each group to collaborate on a preference prediction task. During the presentation stage, students can use the AI Q&A function on the Chaoxing Learning Platform to raise questions, and AI will provide immediate explanations or knowledge supplements, helping students correct misconceptions and deepen their understanding of the formulas. Subsequently, teachers can use the AI recommendation system simulator to dynamically demonstrate the personalized recommendation logic based on conditional probability and total probability calculations, allowing students to visually experience the recommendation system's operation. At the end of the class, the AI data analysis function generates a detailed learning report, covering students' participation, quiz scores, and discussion records, helping students clearly identify their weak points while also providing teachers with valuable support in summarizing the course content and clarifying the application logic of conditional probability and the total probability formula in recommendation systems.

3.3. Post-class consolidation learning

In the post-class phase, AI recommends suitable learning resources based on students' classroom performance, helping weaker students fill in gaps and providing advanced resources for high-performing students. In the discussion area, AI answers common questions, while teachers focus on addressing difficult points, reinforcing

students' understanding of the knowledge. Additionally, AI-generated personalized mistake analysis and class error reports effectively assist in targeted revision, helping students overcome learning bottlenecks. Furthermore, the post-class comprehensive learning report allows both teachers and students to fully understand the learning progress, providing a scientific basis for personalized guidance, ensuring that every student can comprehensively master the practical application of conditional probability and the total probability formula. Through this full-process teaching design, the deep integration of the Chaoxing Learning Platform and AI technology has truly realized a closed-loop learning model that spans pre-class flipped learning, in-class deepening, and post-class consolidation, greatly enhancing teaching efficiency and learning outcomes.

4. AI Empowered multi-dimensional and process-oriented teaching evaluation system and assessment methods to enhance teaching effectiveness

In modern education, constructing a scientific and comprehensive teaching evaluation system is crucial. The introduction of AI technology provides strong support for achieving this goal. Through data analysis and intelligent evaluation, AI not only focuses on learning outcomes but also delves into the details of the learning process, enabling precise evaluation and personalized guidance.

4.1. AI-assisted teaching evaluation system

(1) Personalized Evaluation Mechanism. AI technology analyzes students' online learning behaviors, assignment completion, classroom interactions, and other data to provide teachers with personalized feedback. This helps adjust learning paths to maximize learning outcomes. AI systems can also offer instant feedback and suggestions, helping students identify and address knowledge gaps.

(2) Combination of Process-Oriented and Outcome-Oriented Evaluation. AI helps teachers track students' learning progress in real-time and conduct process-oriented evaluations, allowing for the timely identification and resolution of learning difficulties. This avoids relying solely on final exams for evaluation, ensuring that the assessment is comprehensive and accurate.

4.2. AI-assisted multi-dimensional assessment

(1) By dynamically tracking students' learning processes, AI can assess learning attitudes, participation, and practical abilities in real time, helping teachers adjust their teaching strategies.

(2) AI Integration with "Learning through Competitions." AI can recommend competitions such as mathematical modeling and statistical modeling contests, tracking students' innovation, problem-solving skills, and teamwork performance, which can then be incorporated into the assessment system.

(3) AI Integration with School-Enterprise Collaboration. Schools and enterprises can collaborate through AI platforms to customize courses and practical projects. When students participate in enterprise projects, AI evaluates their task completion, innovation, teamwork, and other performances in real time, incorporating these data into the evaluation system to ensure a comprehensive assessment of students' abilities.

5. Conclusion

This paper explores the use of AI technology in teaching probability theory and mathematical statistics to

optimize the teaching process and enhance learning outcomes. It discusses how AI, through knowledge graphs and recommendation systems, can structure and visualize course content, helping students better understand key concepts and personalize their learning resources. AI supports blended learning, especially in flipped classrooms, by enabling pre-class self-learning and real-time tracking and feedback on students' progress. In-class, AI enhances student interaction and allows teachers to provide targeted support based on real-time data. Finally, the paper explores a diversified AI-assisted evaluation system that tracks learning progress and assesses students' creativity, teamwork, and practical skills, promoting innovation through project-based learning and competitions.

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Disclosure statement

The authors declare no conflict of interest.

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