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Digital Transformation and Application of Blended Teaching of Probability Theory and Mathematical Statistics

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Abstract: As the digital transformation of education continues to advance, the traditional teaching model of "Probability Theory and Mathematical Statistics" —a core course in higher education that combines profound theoretical foundations with practical application—has increasingly revealed pressing challenges such as low teaching efficiency, weak practical components, and difficulties in providing personalized learning guidance. Grounded in the advanced principles of blended learning, this paper explores how to organically integrate digital and intelligent technologies, including but not limited to artificial intelligence, big data analytics, and virtual simulations, into every aspect of the course. It proposes a systematic closed-loop teaching model: "Intelligent Pre-class Preparation—Interactive In-class Exploration—Personalized Post-class Extension." Specifically, this involves building a resource repository rich in digital teaching materials, developing an intelligent assessment system with real-time learning feedback, and designing multiple practical virtual experiment scenarios. These efforts aim to dynamically optimize course content, accurately profile students 'learning processes, and deeply cultivate their practical skills. Practical applications demonstrate that this transformation not only significantly enhances students' learning initiative and enthusiasm but also effectively improves their ability to apply knowledge and solve real-world problems, providing a feasible reference framework and valuable experience for the digital and intelligent reform of mathematics courses in higher education.

Keywords: Probability Theory and Mathematical Statistics; Blended Teaching; Digital Transformation; Teaching Model; Virtual Simulation

Introduction

As a mathematical discipline dedicated to exploring the inherent patterns of random phenomena, Probability Theory and Mathematical Statistics has extensive applications across engineering, economics, medicine, and other fields. The quality of this subject's teaching directly determines students' ability to master quantitative analysis methods and problem-solving skills. In traditional teaching models, instructors typically use a "blackboard + PPT" approach, which often makes theoretical knowledge seem overly Abstract and difficult to grasp. Moreover, there's a significant disconnect between case studies and real-world applications, leading to relatively low student engagement and learning interest. To address these issues, blended learning has emerged as a solution, combining online and offline instruction to provide new approaches for curriculum reform. However, blended learning still has considerable room for improvement in areas like data-driven precision teaching and intelligent resource provision. With the continuous development of digital and intelligent technologies, we now possess the technical support to overcome these challenges, which has also driven the transition from traditional "experience-driven" teaching models to more efficient "data-driven" approaches.

1 The Necessity and Core Objectives of Digital and Intelligent Transformation

(1)The Imperative for Educational Transformation: Traditional teaching models exhibit three critical shortcomings. First, abstract concepts like axiomatic probability definitions and the Law of Large Numbers prove challenging to grasp through conventional lectures. Second, complex computational processes—particularly in multidimensional stochastic variable distributions—require tedious mathematical derivations that overload students. Third, the disconnect between theoretical knowledge and practical application prevents students from reinforcing learning through real-world practice. Furthermore, blended learning faces systemic challenges: online resources lack diversity and innovation, while fragmented learning data makes systematic analysis impractical. Outdated personalized feedback mechanisms hinder timely adjustments to individual needs, undermining the "teaching according to students' aptitude" philosophy. Most crucially, industry demands necessitate educational transformation. The big data era requires enhanced data analysis skills, necessitating curriculum reforms that emphasize statistical software proficiency (e.g., Python, SPSS) and real-world modeling capabilities to cultivate high-caliber professionals meeting contemporary demands.

(2)Core Objective: To achieve comprehensive intelligent management of teaching resources, we aim to establish a dynamically updated and continuously optimized repository of micro-lecture materials, teaching case studies, and algorithmic frameworks. This system will precisely match learning progress and individualized needs across students. Building on this foundation, we strive to refine the teaching process by conducting in-depth analysis of learning behavior data. Through this approach, we can accurately identify each student's learning weaknesses and knowledge gaps, then provide customized learning pathways to enhance educational outcomes. Additionally, we emphasize visual presentation of practical components, leveraging advanced virtual simulation technology to vividly demonstrate the formation of random phenomena. Examples include step-by-step generation of normal distribution curves and simulated demonstrations of statistical significance in hypothesis testing. These intuitive visualizations effectively strengthen students' understanding and cognitive abilities, transforming abstract theoretical knowledge into more accessible and engaging content.

2 Construction of Digital and Intelligent Hybrid Teaching Mode

(1)Instructional Framework Design: Grounded in the blended learning philosophy of "online self-directed learning + offline in-depth discussions," this framework integrates digital tools to create a three-phase closed-loop teaching model. First, during the pre-class smart preview phase, teachers utilize the WPS Docs platform to distribute detailed preview tasks embedded with AI voice-guided micro-lectures (e.g., animated demonstrations of "relationships and operations in random events") to help students grasp abstract concepts visually. Simultaneously, an intelligent question bank system (e.g., WPS Sheets with formula editors) delivers foundational practice questions. After students complete answers, the system provides real-time feedback and automatically generates error rate reports. Teachers leverage this data to precisely adjust classroom focus and difficulty levels, ensuring targeted instruction. Second, in the in-class interactive exploration phase, the "problem-driven" teaching model stimulates students 'investigative interest. Using WPS Sheets' real-time data visualization feature, teachers demonstrate "frequency stability in dice experiments" on-site. Students submit experimental data via QR code scanning, and the system dynamically generates frequency distribution histograms to visually present results. Additionally, an AI teaching assistant system provides real-time answers to classroom questions (e.g., "approximation conditions for binomial and Poisson distributions") while recording high-frequency queries to create teaching improvement lists for future reference. Finally, in the post-class personalized extension phase, the system delivers tiered tasks based on students' learning profiles to meet diverse educational needs. At the foundational level, students complete textbook exercises and use WPS Premium's exclusive formula recognition and grading features for self-assessment to ensure mastery of core concepts. Advanced students engage in real-world case studies (e.g., "Constructing a Probability Model for E-commerce Platform Purchasing Behavior") to enhance practical application skills. Additionally, students conduct comprehensive experiments using virtual simulation platforms (e.g., MATLAB/Simulink) to simulate "Hypothesis Testing Processes in Production Line Quality Control." After completing these experiments, students submit reports to WPS Drive, where instructors provide online feedback, forming a complete teaching cycle to comprehensively improve instructional effectiveness.

(2)Application of Digital and Intelligent Tools in Education and Learning: This domain application is crucial as it can significantly enhance teaching efficiency and learning experiences. A key application involves building intelligent resource libraries that integrate WPS's mind mapping features to organize and construct knowledge systems. For instance, mind maps can be used to compare different probability distributions like normal and binomial distributions, visually demonstrating their differences and connections through tree diagrams. Additionally, these libraries can embed Python code snippets, such as generating random numbers using the NumPy library or simulating Monte Carlo methods. Such functionality allows students to edit and run code online, deepening their understanding of programming and mathematical concepts. Another critical application is developing case libraries linked to real-world data in fields like financial risk control and medical statistics. For example, in financial risk control, Bayesian probability models for credit card fraud detection can be introduced; in medical statistics, hypothesis testing for vaccine efficacy can be incorporated. Through WPS's data visualization plugins, these cases can generate dynamic charts to help students intuitively understand and analyze data. Furthermore, digital and intelligent tools can be used to develop learning analytics systems. Leveraging WPS Education Edition's learning behavior tracking feature, the system can collect data such as students' online video viewing duration, exercise accuracy rates, and forum question keywords. Through clustering algorithms, these datasets can be categorized into distinct learning groups—such as "theory-deficient" and "practice-deficient" —to provide teachers with tailored group instruction strategies. Virtual simulation experiments represent another key application of digital intelligence tools. A "Stochastic Process Visualization Lab" can be established to demonstrate abstract concepts like Brownian motion and Markov chain transitions, enabling students to grasp complex theories through intuitive visual demonstrations. Additionally, a "Statistical Modeling Practice Platform" can be developed, integrating real-world datasets such as the Iris dataset and stock price data. Through drag-and-drop operations, students can perform data cleaning, model selection (e.g., linear regression or logistic regression), and result interpretation, thereby enhancing their practical skills and data analysis capabilities.

3 Practice Effect and Reflection

(1)Case Study Details: At a prestigious university's STEM program, the innovative teaching model was fully implemented for the 2023 freshman cohort (120 students). After one semester of application, systematic data comparison between this group and traditional classes revealed remarkable improvements in educational outcomes. Specifically, students' task completion rates on online learning platforms surged by 42 percentage points, demonstrating significant progress in self-directed learning and task execution capabilities. Final exam scores improved by 15.3 points, reflecting both deeper knowledge mastery and the optimized teaching model. Notably, practical questions involving statistical software operations saw a qualitative leap in student performance, with the pass rate rising from 58% to 82%. This marked substantial enhancement in hands-on skills and practical application abilities. Even more encouragingly, participation in high-level mathematical modeling competitions saw a 30% increase in awards compared to previous years. These achievements not only validate the effectiveness of the teaching reform but also highlight students' comprehensive improvement in innovative thinking and problem-solving capabilities, showcasing their enhanced overall competence and competitiveness. This series of data and results undoubtedly provide a strong support and valuable experience for the further optimization and innovation of the teaching mode in the future.

(2)Reflection and Optimization Directions: In the current process of educational informatization, we must not only focus on the introduction and application of technology but also deeply reflect on and optimize our educational practices. First, the compatibility of technology is a critical issue. We need to simplify the operation processes of certain tools. For example, when developing interfaces between WPS Forms and Python, we should consider students 'technical proficiency thresholds, striving to make operations more intuitive and accessible so they can better utilize these tools for learning and research. Second, data security remains a vital concern. We must strictly adhere to educational data privacy regulations and adopt WPS Private Cloud storage for learning behavior data, effectively safeguarding information security and preventing personal data leaks. Finally, the transformation of teachers' roles is an urgent issue. We need to enhance teachers' digital and intelligent skills training, such as equipping them with AI tool applications and data analysis methods, enabling them to transition from "knowledge transmitters" to "learning designers" who can better guide students in their studies and research. In summary, we need to conduct in-depth reflection and optimization in areas like technological compatibility, data security, and teacher role transformation to advance educational informatization and improve the quality and efficiency of education.

4 Conclusion and Prospect

The course "Probability Theory and Mathematical Statistics" is undergoing profound transformation amid the digital and intelligent transformation. This evolution transcends mere updates to teaching methods—it represents an advanced hybrid learning model. By integrating cutting-edge information technology, it achieves comprehensive optimization across teaching resources, instructional processes, and evaluation systems. This digital transformation presents unprecedented opportunities and challenges for the course. First, generative AI technology enables the GPT model to automatically generate personalized exercises and case analyses, significantly enhancing resource efficiency. Such tailored materials better meet students 'learning needs and improve educational outcomes. Second, interdisciplinary collaboration with engineering and business disciplines allows developing digital teaching modules that integrate probability statistics with professional scenarios. These modules strengthen practical application, helping students master real-world implementations of probability theory. Third, establishing a lifelong learning platform provides alumni with a professional community. By sharing industry-leading case studies like probability models in AI algorithms, we create sustainable connections between academic learning and career development. Ultimately, this digital transformation isn't just about upgrading tools—it's about reinventing educational philosophies. It is student-centered and data-driven, transforming abstract mathematical knowledge into perceptible, applicable and innovative practical abilities, ultimately serving the cultivation of high-quality interdisciplinary talents. This transformation will undoubtedly open up broader development prospects for the course "Probability Theory and Mathematical Statistics".

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