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The Inquiry and Practice of Higher Mathematics Teaching Reform

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Abstract: This paper explores the integration of online and offline teaching modes in higher mathematics using a learning platform to enhance students' learning outcomes and engagement. First, drawing on UNESCO's research on the digital transformation of education, this study outlines the three stages of digital transformation in higher education and proposes innovative online and offline teaching models tailored to the characteristics of basic higher mathematics courses. The development of online courses enhances students' autonomous learning abilities through flexible learning methods and diverse learning resources, including electronic textbooks, videos, and assignments, as well as personalized learning support. Additionally, the online teaching platform fosters interaction, communication, and self-assessment, increasing the flexibility of learning in terms of time and space. Online tests and assignments help prevent plagiarism by utilizing randomly generated question banks and requiring students to upload photos of their handwritten calculations, thereby improving teaching quality. The integration of online and offline learning also emphasizes the connection between professional knowledge and higher mathematics, the incorporation of ideological and political education into the curriculum, and the application of mathematical modeling, further stimulating students' interest and practical skills. Evaluations from both students and teachers demonstrate that this model effectively enhances students' enthusiasm for learning and improves teaching efficiency. Finally, this paper discusses the prospects of applying the Learning-Pass platform to higher mathematics teaching in the context of digital education transformation and provides recommendations for further optimizing the teaching model.

Keywords: Higher mathematics; Online course; Teaching reform

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1. Introduction

In May 2022, the UNESCO Higher Education Innovation Center and the Institute of Education at Tsinghua University published a research report on the digital transformation of higher education teaching. The report categorizes digital transformation into three stages: the integration stage of digital technology and teaching, the primary stage, and the advanced stage [1]. During the integration stage, digital technology is incorporated into curriculum teaching, breaking the constraints of time and space. Core elements such as teaching objectives, content, activities, assessments, and learning environments are re-optimized within the blended physical and digital space. In the primary stage of digital transformation, students gain greater flexibility in learning through hybrid methods that combine online and offline instruction. Educational institutions expand digital learning environments and actively promote hybrid teaching reforms. In the advanced stage, digital technology fully eliminates institutional barriers, fostering collaboration among universities, industries, and other stakeholders. This stage facilitates the sharing of resources—including academic programs, courses, faculty, infrastructure, and services—maximizing the efficient use of educational resources across society and promoting educational equity and lifelong learning [2,3]. Higher mathematics has long been a core requirement in engineering, science, agriculture, and other disciplines. However, its theoretical complexity often diminishes students' interest in learning. This study aims to develop a high-quality higher mathematics course through the collaborative efforts of educators, providing students with an improved learning experience and a robust support platform to enhance their academic efficiency.

2. Course organization and construction

2.1. Construction of online courses

2.1.1. Overall design of online courses

Compared to traditional offline courses, online higher mathematics courses differ in learning methods and homework structure. In traditional offline courses, students attend five class hours per week. However, online learning offers greater flexibility, allowing students to access course materials at any time and from any location. By utilizing the learning platform, course resources are uploaded in advance for students to preview, study, and review, thereby maximizing their use of spare time [4]. These course resources primarily include a digital version of the textbook, chapter-based teaching PPTs, instructional videos, assignments, a syllabus, and a teaching calendar. Through independent pre-class learning, students develop a foundational understanding of the material, allowing them to identify concepts they find challenging. They can then focus on these areas during offline classroom sessions, facilitating a more targeted and efficient learning process [5,6].

2.1.2. Construction of learning environment

Offline teaching is typically conducted in class units to facilitate structured management. To enhance online independent learning, a structured environment has been developed, incorporating "student registration–Superstar Learning–class formation–communication and interaction." Online classes provide greater convenience than offline ones, allowing students to engage in discussions and interact with both peers and instructors. When students encounter difficulties, they can promptly seek clarification from teachers and collaborate with classmates. In online teaching environments, instructors play a crucial role as organizers and supervisors, ensuring seamless learning experiences and providing comprehensive support for students [7,8].

2.1.3. Online teaching tests and assignments

To enable students to evaluate their learning progress and identify areas for improvement, we have designed a structured system of assignments, chapter tests, and mock exams.

Assignments are distributed after each lesson to reinforce newly learned concepts. These assignments are categorized into four types: multiple-choice, fill-in-the-blank, comprehensive, and calculation-based questions. The number of questions per assignment ranges from 4 to 10, depending on the chapter content. The complexity of the questions is aligned with the course material and adapted to students' learning characteristics [9,10]. To prevent plagiarism, assignments are randomly generated from a question bank, ensuring variation while maintaining consistency in knowledge coverage. For calculation-based questions, students submit handwritten solutions via photo uploads, which teachers then review digitally. This process significantly reduces paper usage while enabling students to store and access their work conveniently.

Chapter tests are administered after the completion of each chapter to assess students' grasp of key concepts. These tests include question types similar to those found in assignments and maintain a moderate level of difficulty. To enhance motivation and encourage self-assessment, chapter tests have set time limits, but students can choose when to take them based on their schedule. Additionally, they have the opportunity to retake tests focusing on specific knowledge areas to reinforce their understanding [10,11].

Mock exams are conducted three times throughout the semester. Unlike regular assignments and chapter tests, these exams must be completed within a fixed timeframe, and students are allowed only one attempt per exam. The results help students gauge their overall progress, identify knowledge gaps, and prepare effectively for the final examination at the end of the semester. By implementing this structured online course design, students can take advantage of flexible learning while maintaining engagement and achieving academic success.

2.2. Transformation of the offline teaching model

2.2.1. Integration of professional knowledge and higher mathematical knowledge

Higher mathematics is primarily designed for students in science and engineering disciplines. However, the complexity of its content often discourages students even before they begin studying it. Additionally, many students struggle to understand the practical significance of learning this foundational knowledge. The primary source of students' learning motivation stems from the sense of achievement gained when they successfully apply theoretical concepts from textbooks to solve real-world problems.

Integrating professional knowledge with fundamental concepts in higher mathematics can enhance students' interest in learning by demonstrating the relevance and applicability of mathematical principles within their respective fields. This approach fosters a deeper understanding of how mathematical foundations support their majors, ultimately strengthening their motivation to learn.

For instance, when teaching differential equations to environmental engineering students, instructors can illustrate their practical applications in environmental monitoring. In this field, data related to water quality, air quality, and soil pollution are frequently collected and analyzed. These environmental parameters fluctuate over time and are influenced by various factors. By applying differential equations, mathematical models can be developed to describe these temporal changes. For example, differential equations can be used for curve fitting to predict trends and future developments in environmental indicators [12].

This method not only facilitates a better understanding of current environmental conditions but also enables the prediction of future environmental changes, providing a scientific basis for environmental protection and policy decision-making. To further reinforce this concept, a concrete classroom example can be presented:

In a lake pollution treatment project, researchers observed that the concentration of pollutants in the lake (measured in mg/L) changes over time (in days) and can be modeled using the following differential equation:

$$\frac{dF}{dt} = -kF(t) + C$$

Where $F(t)$ is the concentration of pollutants over time t, k is the natural degradation rate of pollutants (unit: D^{-1}), and C is the rate of pollutants imported into the lake by external sources (unit: mg/L/D). Suppose that the concentration of pollutants in the lake at the initial time $t = 0$ is F_0 mg/L, and $k = 0.05$ D^{-1} is known and $C = 1$ mg/L/D,

Question 1: Find the expression for pollutant concentration, $F(t)$

Question 2: How many days will it take for the concentration of pollutants in the lake to fall below the safe level 5 mg/L?

Through the above practical problems, students can learn to apply the knowledge and stimulate their motivation and interest in learning, transforming passive learning to active learning and enhancing students' independent learning ability.

2.2.2. Integration of ideology and politics into the curriculum

Educating students for the Party and the country is a fundamental objective of education. Higher mathematics is one of the first courses students encounter upon entering university, and it comprises a significant number of instructional hours. At this stage, integrating ideological and political education into the curriculum can have a profound educational impact. By deeply exploring the ideological and political elements embedded in teaching methods, fully utilizing the primary role of curriculum-based education, and embedding ideological and political education throughout the teaching process, we can comprehensively advance its integration into the course. This approach fosters students' values in both knowledge acquisition and skill development while fulfilling the fundamental task of "cultivating morality and talent." Furthermore, it reinforces the mission of educating students for the Party and the country by instilling a sense of identity with socialist core values and a commitment to serving the nation through science and technology. This ensures the organic integration of education and ideological cultivation, ultimately achieving a true unity of the two [13].

Through specific cases of ideological and political integration in the curriculum, not only does this approach play a significant educational role, but it also enables students to appreciate the intellectual beauty and practical charm of higher mathematics.

2.2.3. Integration of mathematical modeling and higher mathematics knowledge

When teaching higher mathematical theories, incorporating mathematical modeling enhances students' interest in learning, stimulates their curiosity, and cultivates both practical and innovative abilities. For example, when discussing extrema, students learn that in mathematical modeling, resource allocation problems can be solved using linear or nonlinear programming optimization methods. When covering differential equations, students see their application in modeling population dynamics. For derivatives, real-world applications are demonstrated: in physics, derivatives describe quantities such as velocity and acceleration, while in economics, they help analyze the rate of change of variables like output and cost [14]. Similarly, integrals play a role in traffic flow modeling, where they describe the accumulation of traffic over time. By aligning mathematical modeling problems with classroom content, students develop a stronger desire to solve real-world problems. This approach transforms higher mathematics from a seemingly abstract and tedious subject into one that is both practical and widely applicable.

3. Effect evaluation of the course

3.1. Student evaluation

Through a combination of online and offline learning throughout the semester, significant improvements have been observed in students' engagement, homework completion rates, and accuracy. Additionally, student evaluations of the instructor indicate increased enthusiasm for learning compared to previous cohorts. More students appreciate the teaching methods employed, and many find that higher mathematics is not as monotonous as they initially perceived. Overall, students exhibit a more active learning attitude and heightened interest in the subject.

3.2. Teacher evaluation

Faculty members in the teaching and research group utilize the Superstar Learning platform to deliver course content. They generally agree that most students complete their assignments effectively, which reinforces their understanding of key concepts. Moreover, the platform enables teachers to track students' learning progress and provide better supervision. This contributes to the development of a positive learning environment [15]. School supervisors conduct comprehensive evaluations of both teachers and students by assessing classroom participation, student presentations, online course quality, and assignment completion. Their observations suggest that the blended online and offline approach to higher mathematics, supported by Superstar Learning, is well-structured and rich in content. The platform also provides students with easy access to learning materials, allowing them to study and practice at their convenience.

4. Conclusion

This study proposed a blended teaching model for higher mathematics that integrates online and offline learning. Throughout its implementation, the model combines professional and mathematical knowledge, incorporates ideological and political education into the mathematics classroom, and enhances mathematical explanations through modeling applications. Preliminary findings verify the feasibility and effectiveness of this approach. The advanced features of the learning platform provide strong technical support for classroom instruction. Furthermore, the online courses developed through the platform have significantly improved students' enthusiasm for learning and overall academic performance.

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