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Research and Practice of Blended Teaching Model in University Mathematics—A Case Study of City Institute, Dalian University of Technology

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Abstract: Starting from the characteristics of students at application-oriented undergraduate institutions, this paper takes Dalian University of Technology City College as an example. Using the Chaoxing platform, it explores blended teaching models for university mathematics courses such as Advanced Mathematics and Linear Algebra. The focus of the research includes designing and constructing online teaching content, implementing blended teaching practices, and reforming and implementing course assessment mechanisms, effectively enhancing the effectiveness of university mathematics teaching.

1. Introduction

With the continuous development of Internet technologies, since the Ministry of Education released the "Educational Informatization 2.0 Action Plan" in April 2018, the combination of online and offline "blended" teaching models has become an important direction for curriculum development in higher education institutions under the "Internet+" initiative. University mathematics, as a foundational subject in higher education, plays a crucial role in solidifying students' knowledge base, fostering logical thinking skills, and enhancing student literacy. It also provides methods and bases for the learning of many subsequent courses. Thus, it is imperative for university mathematics teaching to evolve with the times, meet students' learning needs, and continually explore reforms.

2. The Significance of Adopting a Blended Teaching Model in Applied Undergraduate Mathematics

In applied undergraduate institutions, a certain proportion of students have relatively weak mathematical foundations and lack interest in mathematics courses [1]. For example, students at Dalian University of Technology City College face challenges due to the complexity, multiple properties, high abstraction, and strong logic of university mathematics courses, making it difficult for many students to achieve good learning outcomes with limited offline classroom time alone [2]. In recent years, advancements in information technology and deeper student engagement with the internet, significantly propelled by the COVID-19 pandemic, have promoted the development of online learning. Under these circumstances, advancing a blended teaching model in applied undergraduate mathematics can provide better conditions for students. The research and reform of

adopting a blended teaching model in university mathematics are rapidly evolving, from teaching philosophies [3], content [4], to methods and the use of teaching platforms [5][6]. Drawing on existing research results and based on years of teaching experience, excellent course construction, and recent online teaching practices, we initiated an exploration and practice of blended teaching models in courses like "Advanced Mathematics" (for engineering) and "Linear Algebra" at Chaoxing Learning Pass and other platforms starting from the fall of 2022. In regular offline teaching activities, the advantages of online teaching, such as providing richer learning materials and more flexible learning times, are fully utilized to break through the limitations of offline classroom teaching conditions and create an optimal learning environment aimed at cultivating higher-quality applied technical talents.

3. Design of the Blended Teaching Model for University Mathematics

Starting from the general requirements of higher education and taking into account the characteristics of our students, we design the teaching content and implementation plan for "Advanced Mathematics" and "Linear Algebra" based on the teaching syllabus, distinguishing student understanding and levels.

3.1. Design of Blended Teaching Content and Process

In terms of arranging teaching content and progress, we adopt a progressive approach, focusing on "main thinking" before class, "focusing on key points" during class, and "going deeper" after class to encourage students to complete online learning during fragmented times. Online teaching content includes modules such as "pre-class preparation," "pre-class self-assessment," "course-based political education," "question clarification," "expansion topics," and "direct route to graduate studies." The "pre-class preparation" mainly uses PPT slides to present the basic knowledge points and foundational examples of each lesson. The "pre-class self-assessment" consists primarily of multiple-choice or fill-in-the-blank questions to test students' pre-class preparation and help teachers understand students' basic difficulties in advance. The "course-based political education" module adheres to the principle of "cultivating morality and educating people," using PPT slides or micro-videos to fully integrate teaching and educating by covering aspects such as "national sentiments, grand ideals," "humanistic elements, cultural confidence," "remaining true to our original aspiration, rigorous and pragmatic approach," and "dialectical materialism," and blending these elements into the teaching through both online and offline methods to help students establish correct worldviews, outlooks on life, and values. "Question clarification" serves as a follow-up to teaching, mainly using micro-videos to explain post-class exercises and some difficult concepts, theories, or methods that students find perplexing. The "expansion topics" module sets up more challenging problems to help students with spare capacity or further interest in learning enhance their mathematical abilities and broaden their knowledge. The "direct route to graduate studies" module primarily serves students planning to pursue graduate studies, explaining each session's relevant graduate study points and questions through micro-videos, enabling students to understand graduate-level mathematics from basic learning and plan scientifically for their studies and graduate exam preparations.

3.2. Design of the Blended Learning Implementation Plan

In the implementation of blended learning, while ensuring that the vast majority of students pass assessments smoothly, we consider the needs of some students for graduate entrance examination preparation and participation in mathematics competitions. The implementation plan is designed around the basic teaching segments, competition guidance segments, and graduate exam preparation segments (as shown in Figure 1).

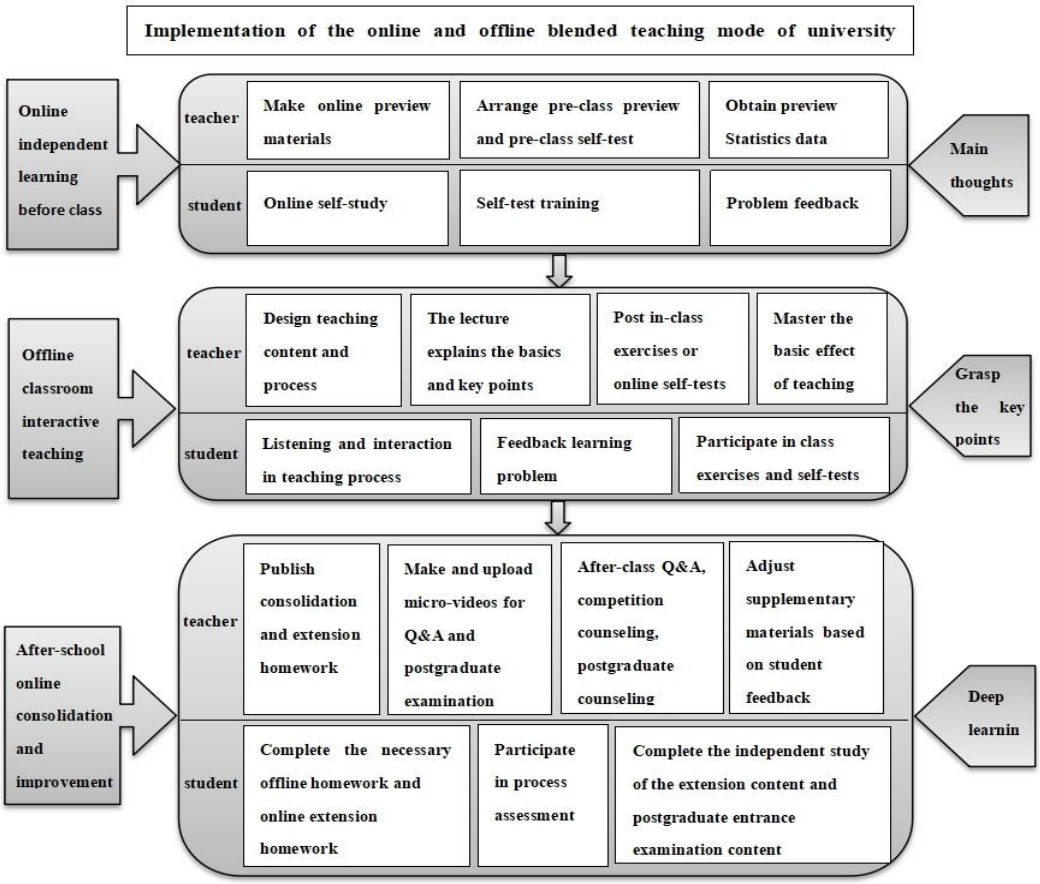

Figure 1: Design of the Blended Learning Implementation Plan

4. Practical Aspects of Blended Learning Model

Based on reforms and adjustments in teaching content and plans, we select classes for practical blended learning implementation. From basic teaching segments to related innovative practices and graduate exam support segments, we aim to meet the learning needs of students at different levels.

4.1. Fundamental Teaching Phases

In the pre-class phase, we prepare and upload preparatory materials well in advance, and at least one week ahead, we issue "pre-class preparation" tasks and "pre-class self-assessment" through the Superstar Learning platform. Students are notified to self-study using textbooks and teaching slides, and based on this, complete a basic "self-test" to check their understanding. Instructors should remind students who have not completed the preparations and self-assessment to study in advance. They use platform data and self-assessment results to gauge students' grasp of foundational knowledge and identify any discrepancies, ensuring that the teaching is more targeted.

During the in-class teaching phase, instructors focus on key educational content, paying attention to providing feedback and addressing common difficulties, and reminding students of any confusions or questions that arose during their preparation. Throughout the course, sporadic in-class exercises or quizzes are conducted to help both students and instructors understand the effectiveness of teaching and learning and to identify any issues.

In the post-class consolidation and enhancement phase, based on the needs of students at different levels, we first use offline essential homework to reflect the foundations and focus of the course

teaching, strengthening all students' grasp of basic knowledge. For those students who are more capable or have goals such as further exams, we use online extension homework to provide a higher level of challenge, encouraging but not mandating completion. After students submit their work online, instructors provide corrections and answers. Through assessing students' responses to basic homework, classroom discussions, and online surveys, we address individual issues on a one-to-one basis and create micro-video solutions for common problems, effectively addressing any lack of classroom teaching time and allowing students to engage in point-to-point self-learning anytime, anywhere, quickly addressing and understanding their learning queries.

4.2. Innovative Practice Phases

Applying learning is also a crucial motivator for students. Therefore, in our routine teaching, we integrate modeling concepts into mathematics education, propelled by competitions such as the National Undergraduate Mathematical Modeling Contest and the Mathematics Competition [1]. Relying on platforms like Superstar Learning, we offer online self-study courses in mathematical modeling and mathematics competition, as well as offline general education courses in mathematical modeling, organizing and encouraging student participation in related competitions. This ignites students' interest in mathematics, enhances their ability to link theory with practice, and improves their overall qualities.

4.3. Graduate Entrance Exam Support Phases

For students aiming at graduate entrance exams, in addition to the "Direct to Grad Exam" module in the basic teaching phase, we establish specialized query groups from the third year of undergraduate studies. Regular posts of foundational problems for the exams are made for check-in training, providing basic explanations and real-time answers. Then, in the first half of their senior year, we offer graduate exam mathematics extension classes, assisting students in their final intensive review and specialized teaching guidance. Through linking all these phases, from basic to final sprint, we strive to create better revision conditions for graduate exam students, enabling them to achieve superior mathematics results in their entrance exams.

5. Assessment Mechanism Reform and Teaching Effectiveness

An effective assessment mechanism can better promote the reform of blended teaching practices. For this reason, we have adjusted the course grading mechanism. The course grade is determined by a weighted combination of regular grades and final exam scores, with regular grades accounting for 30% and final exam scores 70%. The regular grades include attendance (20%), assignments (20%), mid-term exams (50%), and online assessment scores (10%) (as shown in Figure 2). The online assessment part, considering the diversity in knowledge foundations and learning needs of applied undergraduate students, sets "pre-class preparation," "pre-class self-assessment," and "periodic tests" as assessment "task points" that are included in the course grade evaluation. From the perspective of teaching practice effectiveness, students highly accept this adjustment to the assessment mechanism, and the practical outcomes are significant. For example, in the "Linear Algebra" course, 51 fundamental task points were set online, involving 69 students in the teaching practice class. By the end of the course, students completed approximately 8,740 task point activities. In "Advanced Mathematics A (Part II)" (a second-semester course for engineering mathematics), 24 fundamental task points were set, involving 86 students in the teaching practice class, who also completed approximately 8,740 task point activities by the end of the course. The average completion rate of online task points in classes participating in blended teaching practices reached 97%, with a quiz

participation rate of 95%.

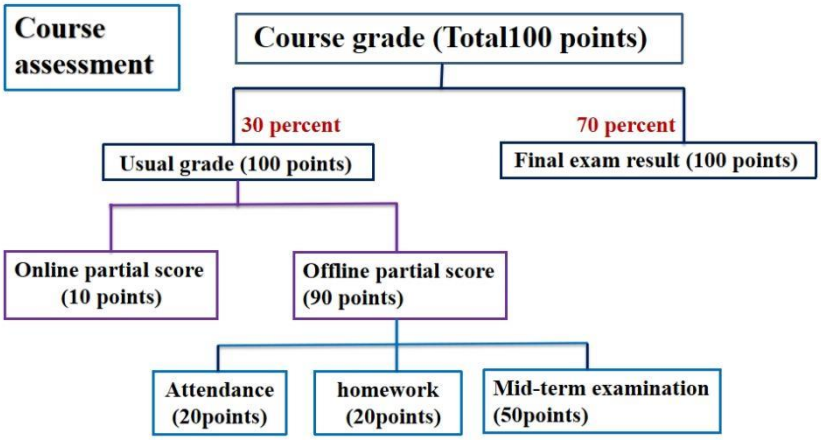

Figure 2: Blended Learning Assessment Mechanism

After a round of teaching practice, we found that the blended learning model significantly stimulated students' interest and initiative in learning mathematics. The "pre-class preparation" and "pre-class self-assessment" encouraged more students to get into the learning state earlier, think proactively, and actively resolve doubts, greatly enhancing their lecture listening efficiency. By guiding students to engage in post-class online self-study, it also clarified the learning objectives for those who needed to learn but did not know where to start, made learning more passionate, and strengthened the execution of self-directed learning, achieving better learning outcomes. Taking the course "Advanced Mathematics A (Part II)" as an example, although the number of students in the practical class changed slightly, the course content was significantly more challenging than the previous semester's "Advanced Mathematics A (Part I)". Generally, grades were not as high as in the previous term. However, after adopting the blended learning approach, the average score, pass rate, and excellence rate of the course all exceeded those of the first semester, with a particularly notable increase in the excellence rate (as shown in Figure 3).

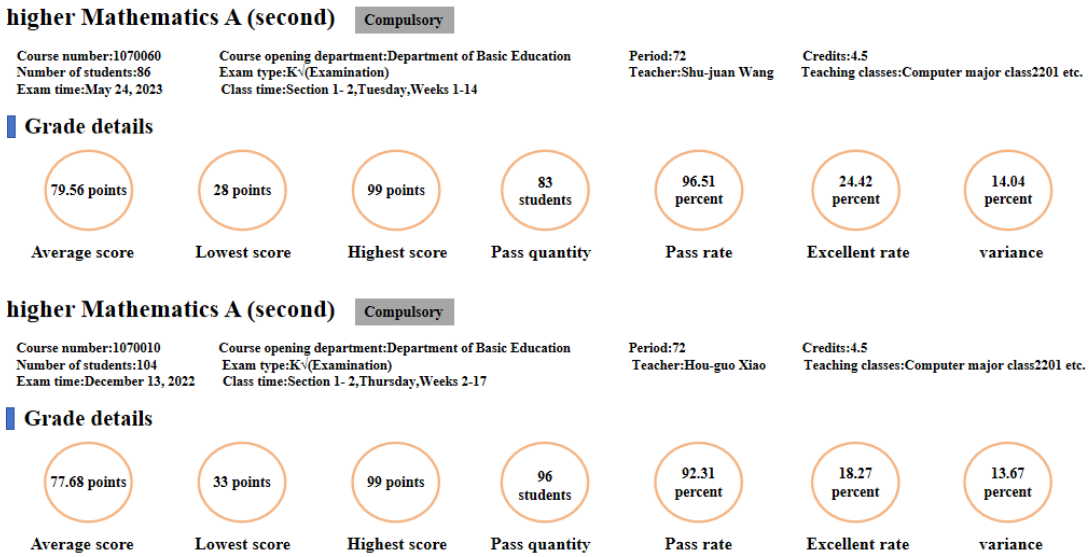

Figure 3: Comparative Effectiveness of Blended Learning

6. Reflections and Prospects on Teaching

After a cycle of educational research and practice, we have recognized that in applied undergraduate institutions, the study and implementation of blended learning in university mathematics requires not only a focus on curriculum content and teaching methods but also an enhancement of the teachers' comprehensive teaching and research abilities. Building a superior teaching team involves utilizing exchanges, training, and competitions. Furthermore, by continuously learning from past experiences and adopting advanced teaching philosophies and methods from leading universities, we can improve teaching materials and optimize the implementation of teaching plans. Fully leveraging the combined benefits of online and offline teaching, we aim to thoroughly ignite students' interest in mathematics, increase their learning initiative, and strive to cultivate high-quality, application-oriented talents that meet the needs of national and societal development.

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