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The Construction and Practical Path of the Online-Offline Integrated Hybrid Teaching System for College Mathematics

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Abstract: *With the application of information technology in higher education, traditional university mathematics classrooms are teacher-led. Due to problems in student participation, independent learning ability and classroom efficiency, it is difficult to adapt to the requirements of comprehensive ability cultivation in the new era. Based on this situation, this article carries out the work of building a hybrid teaching system that integrates online and offline. By reconstructing the course structure, teaching content and learning tasks, the teaching is divided into three stages: "carrying out independent learning before class, conducting interactive exploration in class, and implementing consolidation and expansion after class". It relies on the online platform to integrate micro-courses, question banks and interactive tools to achieve resource release, progress tracking and data recording. At the same time, we build a learning task chain and a multi-dimensional evaluation mechanism to incorporate preview, classroom participation and learning results into the whole process management to improve the level of teaching refinement. Experiments show that blended teaching increases the online homework completion rate from 78.6% to 93.7%, and the classroom interaction participation rate from 42.3% to 68.5%. The degree of learning participation and effect are significantly better than the traditional model.*

Keywords: *University Mathematics Teaching; Blended Learning Model; Online and Offline Integrated Teaching; Learning Task Chain Design; Digital Learning Platform*

1. Introduction

With the deep integration of information technology and education, traditional university mathematics teaching models are facing challenges. Traditional classrooms are primarily teacher-led lectures, with limited student participation and autonomy. This singular approach struggles to meet the current demands of higher education for developing mathematical thinking, logical reasoning, and problem-solving skills, making it a crucial direction for teaching reform. Therefore, exploring more flexible and efficient teaching models to improve classroom teaching quality and learning outcomes has become a vital direction for university mathematics teaching reform.

Based on this situation, this paper focuses on a blended learning model that integrates online and offline learning. By optimizing course structure, teaching content, and learning tasks, a systematic framework and corresponding teaching operation mechanisms and implementation paths are constructed. Comparative experiments are used to analyze its application value in improving student participation and learning outcomes, providing a reference for teaching reform.

2. Related Work

In recent years, blended learning has become an important direction for mathematics teaching reform. Scholars at home and abroad have conducted a large number of empirical studies on its impact on students' grades, abilities and attitudes. Egara and Mosimege used a quasi-experimental design of unequal pre-test and post-test to explore the impact of blended learning on middle school students' mathematics grades and learning retention. The experimental group adopted the blended learning method, while the control group adopted the traditional teaching method. Pre-tests, post-tests and retention tests were conducted. The results showed that blended learning can significantly improve students' mathematics grades and knowledge retention [1]. Jamaluddin et al. used a quasi-experimental

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design of pre-test and post-test to compare the impact of flipped classroom and flexible blended learning on mathematical ability with 128 eighth-grade students and analyzed the role of gender and self-efficacy. The results showed that the flipped classroom was better than the flexible model in improving students' problem-solving ability, but there was no significant difference in concept understanding [2]. Zahedi et al. used a quasi-experimental blended research method to compare the effects of blended learning and traditional teaching in the second-grade mathematics classroom of ABC School in India. After 8 months of teaching experiments, the results showed that the standardized test scores of the experimental group students were significantly higher than those of the control group [3]. Samritin et al. used meta-analysis to analyze 20 effect sizes in 18 Scopus-included studies to explore the impact of blended learning on math performance. The results showed that blended learning significantly improved students' math performance compared to traditional teaching ($d=0.725$, $p<0.05$)[4]. Nührenbörger et al. used quantitative methods to compare the effects of blended learning training and unsupervised online training on teachers' inclusive math teaching attitudes and self-efficacy. The results showed that blended training was more effective in improving teachers' attitudes and self-efficacy[5]. Yudt et al. used a quasi-experimental blended approach to compare the effects of blended learning and traditional face-to-face teaching on primary school teacher trainees' math performance and learning attitudes. The results showed that there was no significant difference in math performance between the two models, but blended learning significantly improved students' learning attitudes[6]. Overall, existing studies generally show that blended learning has a positive effect on improving math performance, learning retention, and learning attitudes, but there are still some differences in the effects on different teaching models and learning ability dimensions.

3. Method

3.1 Design of a Blended Learning System for University Mathematics Integrating Online and Offline Learning

3.1.1 Restructuring of the Blended Curriculum Structure Guided by Learning Objectives

The project involved constructing a blended learning system for university mathematics that integrates online and offline learning. The restructuring of the curriculum system is a valuable foundation of transforming the model of instruction. The instruction will be organized into three stages according to the knowledge system and competence objectives, i.e., online acquisition of knowledge- offline in-depth learning- after-class consolidation and extension. Essentials of the lesson in micro-lessons, materials and minor exercises are also released online prior to the lesson to guide the students to study on their own. The problem based learning assumes the centre of the classroom and discussions and interactions serve to augment the learning and application of the students. The tasks and coursework are given online after the lesson to reaffirm and recap the skills of the students. Such a model opens opportunities to reasonably distribute the resources (online and offline) and classroom hours should be spent more on the analysis of the problems and training of the skills, thereby, increasing the effectiveness of the teaching process.

3.1.2 Modular Organization of Online and Offline Collaborative Teaching Content

In instruction of mathematics on the basis of the blended learning system, one can divide the instructions into units according to the structure of the university knowledge in mathematics: basic knowledge, training of applications, and a general expansion. The demarcation of the functional divisions of online and offline learning needs to be distinct: the basic knowledge module is applied to teach the students the fundamental knowledge with the employment of micro-lectures, online materials and the application training module is also implemented to teach students how to solve the problems using the help of analysis of examples and discussion of examples, the comprehensive extension module considers the comprehensive usage of the knowledge, and involves a combination of online and offline. It is a modular organization and this enhances the hierarchical nature of teaching where there can be a supplementary nature of each teaching component to the other.

3.1.3 Construction of a Learning Task Chain Oriented to Ability Development

The channel that connects teaching contents and the teaching activities is the learning tasks. The sequence of activities surrounding the targets of mathematical comprehension and logical reasoning and problem solving skills are constructed and comprise of the pre-class activity whereby the pre-class activity is delivered in the internet to teach the students the concept and the simple tasks, in-class activity is planned around the significant points of the knowledge and the group discussion and the

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presentation are proposed to make the students think more and the feedback will be given on the platform will guide the teacher on the areas where the students have learnt. This is a systematic task design in which different stages of teaching are associated and mathematical skills of students are developed in a continuity manner.

3.2 Blended Learning Operation Mechanism and Teaching Organization Model

3.2.1 Collaborative Mechanism between Online Self-Study and Offline Classroom Interaction

To balance between online and offline learning, an integrated learning system must comprise of a teaching system, which includes an aspect of student-centered learning, and classroom-oriented interaction. Before the lesson, teachers upload online micro-lessons, instructional materials, and pre-lessons, clarify the learning objectives and necessary facts, and create uncomplicated activities so that students would begin to acquire the knowledge. The site records progress and status of learning exercise done by students which allows the teacher to focus classroom instructions accordingly. During this stage of classroom teaching, teachers address the key points and difficulties students encountered in their pre-class preparation by adopting a problem-oriented teaching approach. Through typical questioning behaviors, group discussions, or case analysis, teachers deepen students' understanding of the knowledge. Simultaneously, they incorporate immediate feedback mechanisms such as in-class quizzes, interactive Q&A sessions, or problem presentations to promptly grasp students' learning progress and address common problems.

Through the online platform, teachers will also publish reinforcement and extension activities to be completed after the lesson where the students will be instructed to practice and summarize what they have learned during the lesson, they would also check on the completion of homework and also analyze the errors made, the effectiveness of learning and even make additional clarifications on the lesson to follow. The sustainability of the online and offline instruction is achieved by the creation of a teaching process of online learning in advance of the classes - interactive inquiry during the classes - consolidation and improvement after classes, the efficiency of the teaching organization is improved.

3.2.2 Teaching Resource Integration and Digital Platform Support Mechanism

Through the online platform, teachers will also publish reinforcement and extension activities to be completed after the lesson where the students will be instructed to practice and summarize what they have learned during the lesson, they would also check on the completion of homework and also analyze the errors made, the effectiveness of learning and even make additional clarifications on the lesson to follow. The sustainability of the online and offline instruction is achieved by the creation of a teaching process of online learning in advance of the classes - interactive inquiry during the classes - consolidation and improvement after classes, the efficiency of the teaching organization is improved.

In the context of blended learning model, the library of digital resources and platform must be properly systematized to make a successful teaching implementation possible. Libraries of digital resources around courses in mathematics in the university should be built, which include micro-lecture video, courseware, sample solutions, online question banks and teaching cases. These resources should be pooled together and organized such that they will form a comprehensive and clear system that will allow the teachers to access them at their own time as means of increasing efficiency in teaching preparation.

Teaching management and learning support tools are taught using online learning tools. Educators use these sites to are given homework, tasks, resources, and track learning in terms of data analytics such as video watching time and homework completion rates as they seek to evaluate the learning process in their students and issue corrections to the instructional arrangement. The platforms also have online discussion forums, real time questions and answers and interactive quizzes that allow interaction between the teachers and the students and ensure a positive learning environment. The integration of resources and support to the platform that assists in controlling and tracking the teaching process make the use of resources more efficient.

3.2.3 Multi-dimensional Learning Evaluation and Feedback Mechanism

To describe the total experience that the students undergo during blended learning, a multi-dimensional system of assessment that would cover the entire process, in other words, online learning behavior, classroom involvement and learning results is needed. Online learning evaluation relies on platform learning statistics, which incorporates such quantitative indicators as video viewing, online activity, and assignments, which demonstrates how the students are already occupied prior to the

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lesson being commenced. The assessment of classroom activity is intended to measure the active discussions of learners, their responses to the questions, and the quality of group work. The teachers or interactive systems make observations in the classroom which encourages student interaction.

Periodic quizzes, unit tests, and final assignments are depended upon to analyze the level of mastery of knowledge and skills on bringing the same into practice. This approach combines formative (integrated throughout the process with multiple feedback points) and summative (comprehensive assessment) evaluation methods. In the process of providing feedback on the evaluation results, teachers will regularly conduct summaries and analyses, and provide suggestions for improvement through classroom or relevant platforms. They will also provide targeted tutoring or resource support for students who have difficulties, thereby promoting learning improvements and optimizing teaching strategies.

3.3 Implementation Path and Continuous Optimization Strategies for Blended Learning

(1) Design of Phased Teaching Implementation Process

For blended learning, a reasonable teaching process is the foundation for achieving teaching effectiveness. A cyclical process of "pre-class – in-class – post-class" should be constructed based on the teaching progress of university mathematics, and the tasks undertaken at each stage should be clearly defined: Before class, teachers should release micro-lessons, handouts, and pre-class assignments through online platforms, and students should complete learning exercises and take online tests for feedback; in class, students should deepen their understanding by addressing difficulties encountered during pre-class preparation through questions, cases, and group discussions, and use in-class exercises for verification; after class, students should consolidate their learning through online assignments, and the platform will record the completion status and errors, which teachers should analyze and adjust to form a cycle.

(2) Transformation of Teacher's Teaching Role and Teaching Methods

The position of the teacher in blended learning is altered to become that of an organizer and guide. During the course preparation stage, the teacher should set a foundation of previewing, exploring, and practicing according to the teaching objectives, prepare micro-lessons and sample solutions to help in answering them to enable self-directed learning. The classroom teaching activities must be organized through the different ways such as introduction of questions, case analysis and group discussion some of which are to assist in guiding the students to think and communicate as well as make summaries and evaluations. The data, that is presented by the online platforms, should help to conduct the analysis of the learning progress of the students, and the guidance can be given depending on the number of the tasks, that are completed, and the number of exercises, that are answered correctly, which would in turn increase the efficiency of the teaching.

(3) Pathways for Continuous Improvement and Quality Assurance in Teaching

To ensure the stable operation of blended learning, the mechanism to ensure the constant improvement and quality control should be presented. The teachers should analyze the learning progress of students based on the data on the online platform, namely, duration of video learning, completion of homework, and errors in exercises. This allows one to optimize what they will be taught and the organization of the classroom and online question and answer or personalized tutoring to those students who might have performed poorly. Meanwhile, the activities, such as teaching reflection and team communication, must aid teachers in generalizing experience and sharing the resources to plan the teaching process in a more effective way and enhance the overall quality of the entire blended learning system.

4. Results and Discussion

4.1 Experimental Subjects and Group Setup

The two parallel first-year courses in the university mathematics course were used as the subjects of the research in this experiment. The classes had approximately 40 students and the entrance exams score was also comparable and the general levels of the mathematical background. To make the comparison of the results of the experiment possible, both classes were taught by the same teacher, and the pace of the teaching process, content, and requirements needed during the examination was the

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same.

Concerning experimental grouping, there was an experimental group, which was a classroom using blended learning model that combined online and off-line learning, and the other group was a control group that used a traditional teaching model lecturing. This experimental period was pegged to one full unit of teaching or a semester where the two groups of students were supposed to finish the course learning activities based on the teaching methods which were in existence.

In the experiment, the experimental group students who had been equipped with online learning platform to engage in pre-class preparation, post class exercises and research learning response and at the same time had to be engaged in both the discussion based and inquiry based learning exercise in the offline classes; students in the control group were largely driven by the lectures given by teachers and homework assigned. The teaching models used in this studying were compared to determine the effectiveness of various teaching models in teaching the same teaching content.

4.2 Data Collection and Evaluation Indicator Design

To be able to fully assess the implementation impact of the teaching model, there is a necessity to gather the information on several levels including learning behavior, classroom involvement and academic performance.

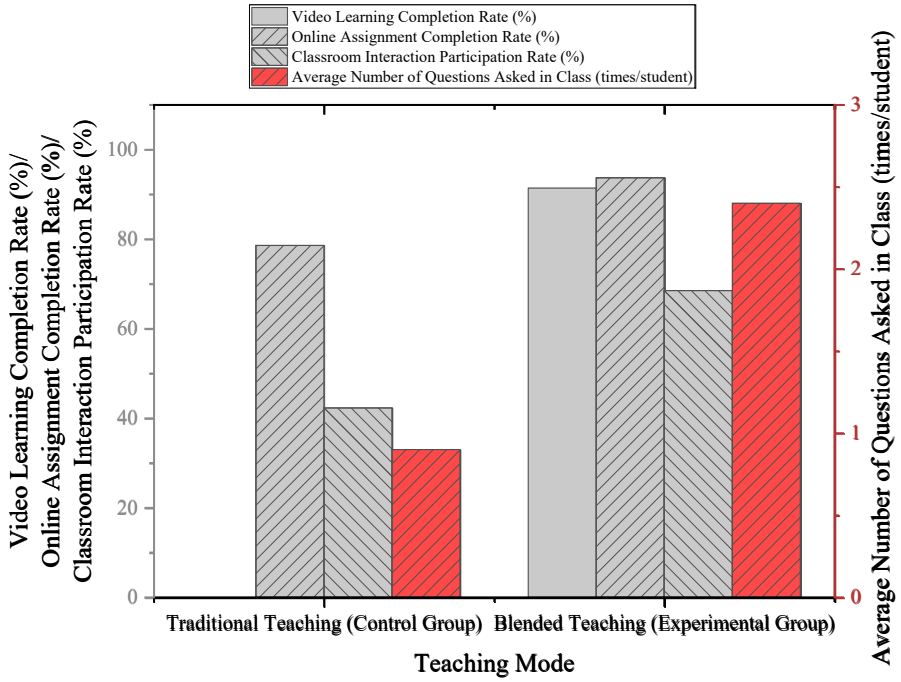

Figure 1. Comparison of student learning participation under different teaching models

Video learning had a 91.4 percent completion rate in the experimental group and this means that the majority of the students could complete the tasks of pre-class online learning in accordance to the teaching requirements which formed the baseline of classroom learning. In terms of homework delivery, the experimental group recorded a high online homework delivery rate of 93.7% compared to the control group of 78.6 percent, and this indicates that the allocation of learning activities and timely delivery of feedbacks by using online platforms is a good way of enhancing student learning initiative.

Furthermore, in classroom learning, the experimental group's classroom interaction participation rate reached 68.5%, a significant increase compared to the traditional teaching model's 42.3%, indicating that blended learning, through methods such as problem discussions and group collaboration, enhances students' enthusiasm for participating in classroom activities. In addition, the experimental group students asked an average of 2.4 questions per student, significantly higher than the control group's 0.9 questions per student, indicating that students are more proactive in learning and communication in a blended learning environment, as shown in Figure 1.

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Table 1. Comparison of student academic performance under different teaching models

Teaching Mode	Average Score	Pass Rate (%)	Excellent Rate (%)	Standard Deviation
Traditional Teaching (Control Group)	72.8	84.1	18.5	10.7
Blended Teaching (Experimental Group)	80.6	93.2	32.4	8.9

The experimental group achieved an average score of 80.6, an increase of 7.8 points compared to the control group's 72.8, indicating that the blended learning model has a positive effect on improving students' overall learning level. In terms of pass rate, the experimental group reached 93.2%, significantly higher than the 84.1% under the traditional teaching model, indicating that this model can effectively reduce the proportion of students with learning difficulties and improve the overall learning achievement level. Regarding the excellent rate, the experimental group reached 32.4%, an increase of 13.9 percentage points compared to the control group's 18.5%, indicating that blended learning also has certain advantages in promoting high-level learning outcomes. Furthermore, the standard deviation of the experimental group's scores was 8.9, lower than the control group's 10.7, indicating that student scores were more concentrated and learning differences were reduced. Overall, the data in Table 1 shows that the blended learning model, which combines online and offline learning, not only improves students' average scores and the excellent rate but also helps to improve overall learning stability, thus promoting the overall improvement of students' learning quality to a certain extent.

5. Conclusion

The paper will center on a blended model of learning mathematics in university which will incorporate the online and offline learning. By the step-by-step design of the course structure, the mechanisms of teaching activities, and the implementation trajectories, a model of teaching organization that has the focus of online self-study before classes, face-to-face interactive questioning after classes, and after-classes consolidation and extension was created and tested in reality in the teaching process. Moreover, integrating both the design of learning task chains and a multi-dimensional evaluation mechanism can, in a certain degree, enhance self-awareness of students in the process of learning and enable classroom instruction to become more efficient. Nevertheless, this research has some shortcomings. As an illustration, the number of participants used in the experiment is very low and only two classes have been chosen to compare. The study time frame is largely confined in a semester and there is no consistent follow up of the long term outcomes of the instructional paradigm. Also, the variations in the academic background of students in various institutions and the discrepancy in the content of the courses can likewise influence the results of the experiment. Further research would be to carry out continuous experimentation with multiple institutions and semesters of learning behavior data analysis and intelligent teaching platform technology to carry out more refined research on the learning process and thus further optimize the implementation strategies of the blended learning model and give the practical implementation of university mathematics teaching reform a more reliable and replicable practical means.

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