Short communication

Exploration and Practice of Teaching Methods for College Mathematics Courses Based on Flipped Classroom

Abstract:
In the context of the information age, the flipped classroom teaching model has brought new inspiration to the reform of higher education. The flipped classroom achieves the transformation of knowledge transmission and internalization through the approach of "online learning and offline internalization". Its personalized and collaborative learning environment helps cultivate students' learning abilities and innovative thinking. In response to the problems existing in current college mathematics teaching, this article has carried out a reform and practice of teaching mode based on flipped classroom. By constructing a teaching process for three stages before, during, and after class, utilizing an information-based teaching platform, and adopting strategies such as project-based learning and collaborative learning, good teaching results have been achieved.

Keywords: flipped classroom; college mathematics; teaching methods; teaching practice

1. Introduction

With the rapid development of information technology, the field of education is undergoing profound changes. Flipped classroom, as an emerging teaching model, has brought new vitality to traditional classroom teaching with its unique teaching philosophy and process. Flipped classroom guides students to learn independently by moving the knowledge imparting stage to before class and using multimedia resources such as videos, while placing the knowledge internalization stage in class [1]. Through interactive communication between teachers, students, and students, difficult problems are solved and understanding is deepened. This teaching mode not only improves teaching efficiency, but also cultivates students' self-learning ability and innovative thinking [1-3]. Flipped classroom has been widely applied in teaching in many fields, such as health science, mechanical engineering, medical, mathematics, business and entrepreneurship education [4-9].

As an important foundational discipline in higher education, the teaching quality of college mathematics directly affects students' professional competence and subsequent development. However, there are still some problems in current college mathematics teaching, such as abstract and difficult to understand course content, single and boring teaching methods, which lead to low students' interest and enthusiasm for learning [10-12]. Therefore, exploring and practicing the flipped classroom teaching model is of great significance for improving the quality of college mathematics teaching.

2. **Methodology**

To explore the effectiveness of the flipped classroom model in college mathematics courses, this study employed a mixed-methods approach.

The methodology for the teaching cases in this study follows a practical, real-world application of

the flipped classroom model in college mathematics. The focus is on the design and implementation of case-based learning to address the challenges identified in traditional mathematics teaching.

3. Definition and characteristics of flipped classroom

Flipped Classroom is a teaching model that reverses the two processes of knowledge transmission and internalization in traditional classroom teaching [2]. In the flipped classroom mode, students learn new knowledge independently by watching videos, reading literature and other methods before class. In the classroom, they internalize and apply knowledge through teacher guidance, group discussions, practical operations, and other methods.

Flipped classroom has the following characteristics:

(1) Initiative: Students actively acquire new knowledge before class, rather than passively receiving teacher's indoctrination. This proactive learning approach helps to enhance students' interest and enthusiasm for learning.

(2) Interactivity: The classroom has become a place for teacher-student interaction and student-student interaction, where students deepen their understanding of knowledge and enhance their problem-solving abilities through communication, discussion, and cooperation.

(3) Personalization: Flipped classrooms allow students to choose learning content and methods based on their own learning progress and interests. So as to achieve the purpose of students' personalized learning.

(4) Technical support: Flipped classroom relies on information technology, such as video production, online learning platforms, etc. Information technology can provide rich and diverse resources and tools for learning of students.

4. Current situation and main problems of college mathematics teaching

(1) The Current Status of College Mathematics Teaching

Currently, traditional teaching models are commonly used in college mathematics education, which focus on teacher lectures while students passively receive knowledge. In this mode, teachers explain mathematical knowledge in the classroom and reinforce students' understanding through examples and exercises. Students complete their learning tasks by listening to lectures, taking notes, and completing assignments.

However, this teaching model has some shortcomings [13-15]. Firstly, due to the abstract and difficult to understand content of college mathematics courses, students often find it difficult to fully comprehend and master new knowledge in the classroom. Secondly, traditional teaching models lack interactivity and personalization, making it difficult to meet the learning needs of students at different levels. Finally, traditional teaching methods can easily lead to low students' interest and enthusiasm for learning, thereby affecting teaching effectiveness.

(2) The main problems in college mathematics teaching

1) The teaching content is too abstract and difficult to understand: The content of college mathematics courses is complex and abstract, and students often find it difficult to understand and master. This leads to students feeling confused and frustrated during the learning process, resulting in a loss of interest and motivation in learning.

2) Single and boring teaching methods: Traditional teaching models often use a single teaching method, lacking interactivity and interest. This teaching method can easily make students feel bored and affect their learning effectiveness.

3) Lack of personalized teaching: Traditional teaching models often overlook individual differences and learning needs of students, resulting in uneven teaching effectiveness. For students with poor foundations, they may not be able to keep up with the teaching progress. For students with a good foundation, they may feel that the teaching content is too simple and lacks challenge.

4) Imperfect evaluation system: The current evaluation system for college mathematics teaching mainly relies on exam scores, which is too single and cannot fully reflect students' learning situation and ability level. At the same time, this evaluation method can easily lead students to adopt exam strategies such as rote memorization in pursuit of high scores, neglecting the cultivation of students' innovative thinking and practical abilities.

5. Teaching Design and Implementation Strategies of Flipped Classroom in College Mathematics Curriculum

(1) Teaching Design of Flipped Classroom

We have explored and practiced the flipped classroom teaching model to address the problems in college mathematics teaching. In teaching design, we focus on the following aspects:

1) Preparation before class: The teacher prepares teaching videos, PPTs, and other teaching resources in advance and uploads them to the online learning platform. At the same time, the teacher design preview tasks and test questions to guide students to learn new knowledge independently.

2) In class interaction: In the classroom, teachers organize students to engage in group discussions, presentations, and other activities. And teachers encourage students to raise and solve problems. At the same time, teachers provide feedback and guidance on students' learning progress. Teachers can help students to deepen their understanding of knowledge.

3) After class extension: Teachers assign homework and extension tasks. Students are required to consolidate their learned knowledge and apply it in practice. At the same time, teachers provide online tutoring and Q&A services to solve problems encountered by students during the learning process.

(2) Implementation strategy of flipped classroom

1) The application of information-based teaching platforms: Utilize information-based teaching platforms (such as Xueyin Online, Smart Tree, Rain Classroom, etc.) to provide students with rich and diverse learning resources and tools. Through online learning platforms, students can watch instructional videos, participate in discussions, submit assignments, and more. At the same time, teachers can also monitor students' learning progress and situation in real time. And teachers can provide targeted guidance and feedback for students.

2) Application of project-based learning: Through project-based learning, students are guided to apply the knowledge they have learned to practical problems. For example, in calculus courses, teachers can design projects related to real life (such as calculating the volume of irregular objects, analyzing trends in economic data, etc.), which can enable students to master and apply calculus knowledge in practice.

3) The development of collaborative learning: Through collaborative learning, students' teamwork spirit and communication skills can be cultivated. In the classroom, teachers can organize students to engage in group discussions, role-playing, and other activities. Students are encouraged to collaborate and complete tasks together. This learning method can not only increase students' participation, but also promote their in-depth understanding and application of knowledge.

4) Implementation of personalized teaching strategies: Adopt personalized teaching strategies based on the learning needs and ability levels of students at different levels. For example, for students with poor foundations, teachers can provide more tutoring and support; For students with a good foundation, teachers can design more challenging learning tasks and expanded content. This teaching strategy can meet the personalized needs of students and improve teaching effectiveness.

6. Teaching Cases

Taking the concept and properties of limits in the course of Advanced Mathematics as an example, we have designed a teaching case based on flipped classroom.

(1) Preparation before class:

On the course platform, pre-record instructional videos to introduce the basic concepts, properties, and calculation methods of limits. Provide relevant reading materials on the definition, theorems, and proof process of limits. Students are required to complete the reading of videos and related materials before class. They can understand the definition of limits, and solve some simple limit calculation problems.

(2) Classroom teaching:

Firstly, the teacher explain the problems encountered by students during their preview. Then students are divide into several groups for discussion. And each group is assigned a mathematical problem related to limits, such as solving the limits of complex functions, discussing the existence of limits, etc. Further the teacher guide students to conduct mathematical experiments, such as using mathematical software to solve limits and observe the changes in limits. Finally, the teacher helps students deepen their understanding of the concept and nature of limits through questioning, guidance and other methods, and provides a summary.

(3) After class reflection and evaluation:

Firstly, students are required to reflect on their learning process after class, such as summarize their understanding of the concept of limits and their mastery of calculation methods. Then, a series of exercises and practical problems related to the concept of limits were designed. And students are require to independently complete them to test their understanding and application ability of the concept of limits. Finally, students' learning outcomes are evaluated from multiple dimensions such as classroom participation, group discussion outcomes, homework completion status, and final exams. At the same time, feedback from students was collected through questionnaire surveys and individual interviews to understand their views and suggestions on flipped classroom.

7. Analysis of practical effects

Through practice, we have found that the flipped classroom teaching method has achieved significant results in the teaching of mathematics courses.

（1） Enhancing students' initiative in learning

In the flipped classroom mode, students need to engage in self-directed learning before class, which forces them to be more proactive in understanding the teaching content, asking questions, and conducting preliminary thinking. In the classroom, students have more opportunities to participate in discussions and practices. And the learning interest and enthusiasm of students have significantly increased.

（2） Improvement of problem-solving ability

The flipped classroom teaching method encourages students to solve problems through

collaboration, researching materials, and other means, which cultivates students' self-learning and problem-solving abilities. In group discussions, students learned how to divide labor and collaborate, how to communicate effectively, and how to think about problems from different perspectives. These experiences not only help them achieve better grades in mathematics learning, but also have a positive impact on their future career.

（3） Improvement of teaching quality

By implementing the flipped classroom teaching method, teachers can pay more attention to individual differences and learning needs of students in the classroom. And students can be provided more targeted guidance and assistance. Meanwhile, as students have already gained a preliminary understanding of the teaching content before class, teachers can delve deeper into complex concepts and issues in the classroom. Thereby the quality and efficiency of teaching are improved.

8. Conclusions

Through the practical exploration of the flipped classroom teaching mode in college mathematics courses, it can be found that the flipped classroom teaching mode has significant teaching effects and advantages. Firstly, flipped classroom can stimulate students' interest and enthusiasm in learning, improve their self-learning ability and innovative thinking; Secondly, flipped classroom can achieve personalized teaching and meet the learning needs and ability levels of different students; Finally, flipped classroom can enhance students' classroom participation and teamwork skills, promoting their comprehensive development. In the future, we will continue to deepen the practical exploration of the flipped classroom teaching model in college mathematics courses. On the one hand, we will further optimize teaching design, improve teaching resources and tools; On the other hand, we will explore more diverse teaching and evaluation methods to better meet students' learning and development needs. At the same time, we will actively communicate and share the experience and achievements of flipped classroom teaching with other teachers, and jointly improve the quality of College Mathematics Teaching.

Acknowledgment

The authors mainly thank the well-known review experts and editors for their suggestions and comments. This work was supported in part by the Research Project on Teaching Reform in Ordinary Higher Education Institutions in Hunan Province (HNJG-2022-0217).

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

References

[1] Zhang JL, Wang Y, Baohui Zhang. Research on Flipped Classroom Teaching Mode [J]. Distance Education Journal, 2012 (4): 46-51.

[2] Zhong XL, Song SQ, Jiao LZ. Research on Teaching Design Based on Flipped Classroom Concept in Information Environment [J]. Open Education Research, 2013 (1): 58-64.
[3] Galindo-Dominguez H. Flipped classroom in the educational system [J]. Educational Technology & Society, 2021, 24(3): 44-60.
[4] Oudbier J, Spaai G, Timmermans K, et al. Enhancing the effectiveness of flipped classroom in health science education: a state-of-the-art review [J]. BMC Medical Education, 2022, 22(1): 34.
[5] Cho HJ, Zhao K, Lee CR, et al. Active learning through flipped classroom in mechanical engineering: improving students' perception of learning and performance [J]. International Journal of STEM Education, 2021, 8: 1-13.
[6] Phillips J, Wiesbauer F. The flipped classroom in medical education: A new standard in teaching [J]. Trends in Anaesthesia and Critical Care, 2022, 42: 4-8.
[7] Senali MG, Iranmanesh M, Ghobakhloo M, et al. Flipped classroom in business and entrepreneurship education: A systematic review and future research agenda [J]. The International Journal of Management Education, 2022, 20(1): 100614.
[8] Bhagat KK, Chang CN, Chang CY. The impact of the flipped classroom on mathematics concept learning in high school [J]. Journal of Educational Technology & Society. 2016, 19(3): 134-42.
[9] Lo CK, Hew KF, Chen G. Toward a set of design principles for mathematics flipped classrooms: A synthesis of research in mathematics education [J]. Educational Research Review. 2017, 22: 50-73.
[10] Zhao Q. The reform path of applied university mathematics course teaching under the concept of general education [J]. Western Quality Education, 2024, 10 (06): 155-158.
[11] Li L, Fang SM, Zhang X. Exploration of Teaching Reform in College Mathematics under the Background of New Agricultural Science [J] Science and Education Guide, 2023, (34): 46-48.
[12] Huang BQ, Ding YH. Research on the Reform of College Mathematics Curriculum Teaching under the Background of New Engineering [J] Science and Education Guide, 2023, (13): 107-109.
[13] Wen KW, Huang HQ. Research on Higher Mathematics Teaching Based on Flipped Classroom Mode [J]. Higher Education Journal, 2021 (01): 78-81.
[14] Yang F. Design and Practice of Flipped Classroom Teaching in Higher Mathematics Based on the Learning Platform [J]. Wireless Internet Technology, 2020, 17 (22): 157-159.
[15] Ying X, Tang XF. Exploration of the Application of Flipped Classroom Teaching Mode in Higher Mathematics Teaching [J]. Study Weekly, 2024 (24): 1-3.