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Integration of Mathematics Culture and Mathematics Teaching in High School under the View of Flipped Classroom

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ABSTRACT

The new curriculum standard suggests that mathematics culture should be integrated into mathematics teaching activities. With the support of information technology, how to better integrate mathematics culture and cultivate students' mathematics cultural literacy has attracted much attention. This paper applies theoretical research methods to explore the combination of mathematical culture with the flipped classroom for teaching mathematical culture. On the basis of clarifying the connotation and characteristics of both mathematics culture and the flipped classroom, and analyzing the current situation of mathematics culture teaching and flipped classroom teaching in high schools, this paper proposes strategies for integrating mathematics culture into high school mathematics teaching within the flipped classroom framework: 1. Creating high-quality microvideos for mathematics culture teaching; 2. Clearly defining students' objectives and tasks for independent pre-class learning; 3. Selecting teaching methods judiciously for effective in-class instruction; 4. Enhancing teachers' own mathematics cultural literacy through reflective evaluation. Through the above strategies, high-quality teaching micro-videos enhance students' interest in learning and their independent learning abilities. Clear independent learning objectives and tasks can effectively improve students' learning efficiency and help them construct their own

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knowledge. Appropriate teaching methods can stimulate students' interest in learning and improve the effectiveness of classroom assessments. With the help of the flipped classroom as a teaching mode, it can assist teachers and students in adjusting and improving their teaching and learning processes, and create a more interesting, diversified, and open learning environment. This environment fosters a deeper appreciation for mathematical culture among students. The aim is to better integrate mathematics culture knowledge and enhance students' mathematical literacy in personalized teaching.

Keywords: Mathematics culture; flipped classroom; high school mathematics; teaching strategy.

1. INTRODUCTION

In the newly revised 'Standards for Mathematics Curriculum in Ordinary High Schools' (2017 edition), it is proposed that mathematics culture should be integrated into mathematics teaching activities [1]. The integration of mathematics culture into the mathematics classroom is an inevitable requirement of modern education. With the continuous development of information technology, the use of new teaching forms can better integrate mathematics culture with high school mathematics teaching. Flipped classroom is a new teaching mode that can fully leverage students' initiative in learning and serves as an effective carrier for infiltrating mathematics culture. The combination of mathematics culture and the flipped classroom represents a new attempt at teaching modes, which can provide a reference for frontline teachers to integrate mathematics culture. This is of great significance for the integration of mathematics culture, the promotion and enhancement of the flipped classroom teaching model, and the cultivation of students' personal qualities.

What are the connotations and characteristics of mathematics culture and the flipped classroom? What is the current status of mathematics culture teaching and the application of the flipped classroom in middle schools? How can the flipped classroom better serve as a carrier for the integration of mathematics culture? This paper will address these questions.

2. THE CONNOTATION AND CHARACTERISTICS OF MATHEMATICS CULTURE AND FLIPPED CLASSROOM

2.1 Connotation and Characteristics of Mathematics Culture

2.1.1 Connotation of mathematics culture

The connotation of mathematics culture is outlined in the new curriculum standard, which states that “Mathematics culture refers to the thought, spirit, language, methods, and viewpoints of mathematics, as well as their formation and development. It also encompasses the contributions and significance of mathematics in human life, science and technology, and social development, as well as the humanistic activities related to mathematics.”

The description of mathematical culture in the curriculum standard reflects a multi-dimensional understanding of culture and its various contents. Among these, the idea of mathematics is the essential understanding of mathematical facts and theories after generalization, such as functional thinking, the concept of equations, the combination of number and shape, classification discussion, transformation and regression, analogy, and modeling. Mathematical language is a scientific language that includes mathematical concepts, terms, symbols, formulas, graphics, etc. The mathematical spirit is the value concept and behavioral norms formed by people in mathematical activities, primarily including the spirit of mathematical rationality, truthfulness, and innovation.

Mathematically related humanistic activities, such as mathematical research, learning, application in life, practice, and innovation, are also part of mathematical culture. Thus, mathematical culture includes not only the ideas, methods, and viewpoints of mathematics but also has a richer and deeper cultural connotation than themathematical knowledge system itself. It is the natural precipitation of mathematics in the course of historical development and represents the sum of material wealth and spiritual wealth created by human social groups in mathematical activities.

2.1.2 Characteristics of mathematics culture

(1) Unification of scientificity and artificiality

Mathematical culture emphasizes the origins and development of mathematical knowledge, as well

as the discovery and research processes of mathematicians. It can reflect the spiritual qualities of mathematicians, such as their courage to question, their pursuit of truth and beauty, and the value and role of mathematics in the development of human thought and daily life. For example, the process of discovering Fibonacci series by Italian mathematician Leonardo of Pisa, known as Fibonacci, profoundly reflects the unity of scientificity and artificiality of mathematical culture [1].

(2) Integration of diversity and inclusivity

Mathematical culture encompasses the learning of mathematics, the development of mathematical theories, and all processes of applying mathematics. It also includes the cultural achievements that arise from these activities, as well as other humanistic activities and achievements related to mathematics. The multi-dimensional content system of mathematical culture includes areas such as mathematics education, the application of mathematics, and the development of mathematical disciplines [2].

(3) Historical and aesthetic blending

Mathematical history is a crucial part of mathematical culture, encompassing the development and evolution of mathematics both domestically and internationally, as well as the history of mathematical problems and ideas. Mathematics possesses an abstract beauty, a symmetry beauty, and a brevity beauty. The aesthetic aspect of mathematical culture is not only evident in mathematical formulas and geometric figures but also permeates every aspect of mathematical history [3].

2.2 Connotation and Characteristics of Flipped Classroom

2.2.1 The connotation of flipped classroom

The flipped classroom originated in the United States and refers to a teaching method where students watch instructional videos during the pre-class learning stage. These videos are microvideos of knowledge learning resources prepared by teachers in advance. Back in the classroom, students discuss their questions, assignments, and topics under the guidance of teachers. This is a teaching form where teachers address questions raised by students or clarify confusing knowledge [4].

Different researchers have different definitions and understandings of the flipped classroom. The author believes that the flipped classroom is a new teaching mode supported by information technology. With the help of pre-class microclass videos, students engage in two processes: post-class knowledge acquisition and classroom knowledge internalization. This approach enhances students' learning participation and fosters independent and cooperative learning skills. The success of the flipped classroom teaching mode hinges on the effectiveness of students' pre-class learning and the quality of classroom interaction and inspection.

2.2.2 Characteristics of flipped classroom

(1) Innovation of teaching resources

With the aid of information technology, knowledge is now delivered through microclass videos, which are characterized by clear objectives, brevity, accuracy, and liveliness. Learning resources have become more diverse, and the presentation of learning data is multifaceted. Teaching videos are extensively utilized, offering the advantage of being unrestricted by time and space, and they can be revisited for learning purposes as needed.

(2) Reconstruction of teaching process

Transforming the classroom teaching model is a process where knowledge is transferred outside the classroom and internalized within it. In this approach, students engage in independent learning by watching videos and reading materials before class. They then participate in discussions, exchanges, and interactions with teachers to internalize the knowledge during class.

(3) Change in learning style

Under the flipped classroom teaching model, students become active learners and explorers, rather than remaining passive recipients as in traditional classroom teaching. Through active learning before class and cooperative interaction between teachers and students during class, students' participation is enhanced, enabling them to truly become the masters of their own learning.

3. ANALYSIS OF THE CURRENT SITUATION OF MATHEMATICS CULTURE TEACHING AND FLIPPING CLASSROOM TEACHING IN MIDDLE SCHOOL

(1) In terms of teaching objectives: Teachers' objectives for teaching mathematical culture are not clear, resulting in a lack of design for relevant mathematical culture instruction. The learning objectives for students in the flipped classroom are not well-structured, leading to low learning efficiency and an inability to effectively stimulate students' interest in learning mathematics.

(2) In terms of teaching objects: Students show interest in mathematical culture, but their understanding is very superficial and incomplete, and the actual integration of mathematical culture is still inadequate. The learning status of students in relation to mathematical culture is passive absorption; they cannot delve deeply into the study of mathematical culture. There is a need to improve students' initiative in learning and their independent learning abilities.

(3) In terms of teaching content: The curriculum standards emphasize the importance of mathematical culture and require its integration into teaching activities. The challenges in teaching mathematical culture are evident in the selection and processing of materials, the weak correlation between mathematical culture content and teaching content, and a lack of existing data that needs further study and organization before use. Most topics related to mathematical culture in curriculum standards are limited to objective narratives of mathematical history, lacking in the infectiousness of mathematical culture and specific implementation methods and requirements. The characteristics of mathematical culture content settings in high school textbooks are reflected in their expansion, assistance, and readability, but students face time and cognitive conflicts in the in-depth study of mathematical culture.

(4) In terms of educational concept: Teachers have not yet transformed their educational concepts, believing that teaching mathematical culture is a waste of time and not valuing it; their teaching models and methods have not been innovative and have remained unchanged from traditional approaches. Some teachers have changed their educational concepts, but without specific practices. Most teachers have a relatively weak humanistic background and low mathematical culture literacy.

(5) In terms of educational model: With the support of information technology, the flipped classroom, as a new type of teaching model of "extracurricular learning, classroom internalization," aligns with the core of China's educational informatization development planning. It caters to the current better teaching hardware environment by having students learn from videos and other high-quality learning resources prepared in advance by teachers. This approach aims to maximize students' learning autonomy, improve their interest in learning, and develop their self-study and communication skills. It can help address the current state of high school teaching that is heavy on knowledge but light on ability, heavy on conclusions but light on process, and characterized by a dull teaching process that overlooks students' dominant position. However, there are practical implementation issues, such as the monotony of teaching videos, excessive online information that interferes with learning, lack of timely responses to students' questions during video learning, and low efficiency in pre-class independent learning.

4. STRATEGIES FOR INTEGRATING MATHEMATICS CULTURE WITH MATHEMATICS TEACHING IN HIGH SCHOOL UNDER THE PERSPECTIVE OF FLIPPED CLASSROOM

To effectively employ the flipped classroom teaching mode for mathematics culture, the following strategies are proposed in accordance with the teaching process and the flipped classroom characteristics of 'extracurricular learning, classroom internalization': pre-class independent learning, classroom knowledge absorption, and post-class reflection and evaluation.

4.1 Producing High-Quality Microvideos on Mathematics Culture Teaching

This strategy is part of the teaching preparation strategy for teachers during the students'

independent learning stage before class. It requires teachers to create teaching microvideos with the help of relevant tools. Teachers can either shoot the teaching microvideos themselves or record them by creating teaching presentations with the aid of screen recording software, electronic whiteboards, and handwriting boards. The microvideos should be concise and well-crafted, with clear teaching objectives and precise design of the mathematical culture content, which can guide students to deepen their understanding of mathematical culture through thought and inquiry, and develop their mathematical thinking and mathematical culture literacy.

Teaching micro-videos represent an innovation in teaching resources. With the help of these videos, the teaching resources related to mathematical culture can become more diversified. Through further research and organization of mathematical culture content by teachers, the use of dynamic video can enhance the appeal of mathematical culture and deepen students' understanding. Because the objective of teaching with micro-videos is highly targeted, it can improve the teaching of specific mathematical culture knowledge points. Therefore, it requires teachers to expand and extend the teaching content, analyze the learning situation, and delve into the connotation and extension of the relevant mathematical culture. This should be done by analyzing the teaching content, the learning situation, and the relevant mathematical culture, and then creating micro-videos that focus on the process and methods, as well as the emotional, attitudinal, and value goals [5-7].

High-quality teaching microvideos can stimulate students' interest in learning, giving them the initiative to learn. Students can also watch the learning materials repeatedly to gain a deep understanding of the rich and profound aspects of mathematical culture. This can effectively address the conflict between the need for efficient, rigorous teaching and the generation of thought in mathematics education, focusing on fostering students' thinking, and enhancing their interest in learning and independent learning abilities.

4.2 Clearly State the Objectives and Tasks of Students' Independent Learning Before Class

This strategy belongs to the teaching preparation strategy of teachers in the stage of students' independent learning before class. According to the teaching objectives and teaching contents of the relevant mathematical culture, teachers are required to clearly give the objectives and learning tasks of students' independent learning before class, so as to ensure that students carry out self-detection according to the learning objectives and learning tasks, and then find out problems and put forward problems, and truly realize the in-depth learning of mathematical culture knowledge before class. For example, teachers can design students' self-learning assessment form before class, design self-learning task list and so on.

The reconstruction of teaching process is a major feature of flipping classroom. The effect of students' learning before class will directly affect the success or failure of flipping classroom teaching. Therefore, teachers should give timely feedback and evaluation to the learning of students' mathematical culture knowledge. In order to achieve this goal, teachers can design the students' independent learning evaluation form including the objectives of pre-class learning, learning content and problems and feelings. In addition, teachers should combine the scientific and human characteristics of mathematics culture, so that students can explore the beauty and value of mathematics in pre-class learning stage.

Taking the "Fibonacci series" in the compulsory A version 5 as an example, through the introduction and guidance of Fibonacci series in microvideo, the self-learning goal before class can be designed as: to recognize Fibonacci series; to understand its examples emerging in real life; and to preliminarily explore the simple nature of Fibonacci series. The self-learning task is designed as follows: through watching microvideos, consulting data, completing the following tasks, the specific tasks can be designed around the Fibonacci sequence of discovery process, examples, nature exploration and so on. In this example, students learn independently through teaching videos and collect data, self-test through learning objectives and tasks, and then discover problems, ask problems, and master relevant mathematical knowledge while improving the ability to learn autonomously [8-10].

Reasonable self-learning objectives and learning tasks can effectively improve students' learning efficiency. Students can realize the formation process of mathematical culture knowledge and

the value of mathematics by studying and collecting data independently before class. The problems found through self-testing also provide a guarantee for them to participate in classroom exploration and complete the construction of knowledge.

4.3 Reasonable Selection of Teaching Methods for Effective Classroom Testing

This strategy is part of the teaching strategy for teachers during the knowledge internalization stage in the classroom. It requires teachers to select and use methods such as "problem-based learning," "case teaching," and "group discussion" effectively. These methods should enable students to engage actively in learning. Teachers should carefully design the teaching process to facilitate effective exploration and activities, tailored to the characteristics and challenges of the relevant mathematical culture knowledge. This approach allows students' understanding of mathematical culture to reach a deeper level [11].

Effective classroom assessment is crucial to the success of this teaching model. During this stage, it is necessary to delve deeper into problems with the aid of communication and discussion among teachers and students. By considering the characteristics of changing student learning styles in the classroom, along with the features and challenges of mathematical culture, teachers can integrate mathematical culture materials and appropriate teaching methods into their lessons. This integration helps to design activities that are conducive to effective classroom assessment.

Mathematical culture encompasses a broad range, diversity, and inclusiveness. The challenge in teaching mathematical culture lies in the selection and processing of its materials, which include the origins of mathematical concepts, historical allusions, and the significance of mathematical symbols, most of which are described in textual materials [12]. Teachers need to uncover the mathematical thought processes, translate them into open problems, or use real-life cases related to mathematical culture for teaching. They should then choose suitable methods such as "problem-based learning," "case teaching," and "reading mathematical history before class," and integrate these into teaching activities that align with student learning. The design of classroom activities should also balance scientific rigor with humanistic elements, consider students' enthusiasm and initiative in the classroom, and encourage group interaction, cooperation, and collaborative learning.

Appropriate teaching methods can stimulate students' interest in learning, enhance the effectiveness of classroom assessments, and enrich students' experiences in the field of mathematical culture through exchanges and discussions among teachers and students. These methods contribute to a comprehensive improvement in students' mathematical culture literacy.

4.4 Enhancing Teachers' Own Mathematical Cultural Literacy in Reflective Appraisal

This strategy pertains to the post-class evaluation stage of teachers' reflection. It requires teachers to first provide feedback and assess students' learning. Then, they should integrate the learning outcomes of students' mathematical culture with the effectiveness of their teaching. Teachers should reflect on their educational philosophy, knowledge of mathematical culture, teaching skills, research abilities, and emotional connection to the subject. Through this process, they can enhance their mathematical culture literacy through ongoing accumulation and gradual improvement.

Feedback and evaluation of student learning serve as auxiliary and guiding elements in teaching. In the flipped classroom model, teachers need to determine whether students have engaged in meaningful independent learning, identify any difficulties they encounter during classroom discussions, and assess their grasp of mathematical cultural knowledge. It is suggested that teachers employ a multifaceted evaluation model based on formative assessment to gather evidence of learning, design instructional content, offer feedback, and reflect on student learning outcomes.

The new curriculum standards highlight the significance of mathematical culture, and teachers' proficiency in mathematical culture is essential for fostering students' own understanding of the subject. To better cultivate students' mathematical culture literacy in middle schools, especially considering the current state of teachers' educational philosophies, outdated teaching methods, and a lack of a strong

humanistic background, it is advised that teachers update their educational concepts. They should focus on teaching mathematical culture, be willing to experiment with new teaching models, and continuously build upon their experiences and skills in mathematical culture knowledge and instruction. This will, in turn, improve their mathematical culture literacy.

In the flipped classroom model, employing a diverse evaluation approach and providing effective feedback can assist both teachers and students in adjusting and enhancing their teaching and learning methods. Enhancing teachers' mathematical culture literacy directly impacts the integration of mathematical culture in the classroom. It can contribute to creating a more engaging, diverse, and open environment for students to learn about mathematical culture [13].

5. CONCLUSION

The curriculum standard emphasizes that mathematics culture should be integrated into mathematics teaching activities [1]. With the development of information technology, with the help of flipped classroom, a new teaching model, appropriate teaching strategies can effectively penetrate mathematics culture in teaching. This paper employs the method of theoretical discourse research, relying primarily on relevant literature from recent years rather than data and inductive methods. It conducts an in-depth analysis of the relevant concepts and the current state of teaching, and subsequently proposes implementation measures. On the basis of analyzing the connotation and requirements of mathematics culture and flipped classroom, combining with the current teaching situation, this paper believes that to effectively integrate mathematics culture into mathematics teaching activities, teachers should make high-quality mathematics culture teaching microvideos, clearly give students' objectives and tasks of independent learning before class, reasonably select teaching methods for effective classroom inspection, and improve their mathematics culture literacy in reflection evaluation[14-18]. However, it is a long and arduous task to infiltrate mathematics culture and cultivate students' mathematics culture literacy in high school mathematics teaching. Teachers should integrate mathematical culture into high school mathematics teaching in a way that is informed by a solid professional foundation, an advanced educational philosophy, and with the support of information technology.

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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 writing or editing of manuscripts.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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