Research on the Value Reconstruction and Practical Path of Mathematical Culture in the Context of Digitalization

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Abstract： With the deepening of curriculum reform and the advancement of digital education, the educational value of mathematical culture has become increasingly prominent. As a vital medium carrying the history and ideas of mathematics, the digitalization of mathematical culture offers new pathways to enhance classroom teaching. This paper focuses on reconstructing the value of mathematical culture in the digital era and explores in-depth integration strategies in classroom instruction from three dimensions: tracing the essence of concepts, grasping mathematical thinking, and expanding real-life applications. Through digital means, it aims to vividly present the developmental trajectory of mathematical concepts, dynamically demonstrate the evolution of mathematical thinking, and build bridges between mathematics and real-world disciplines. At the same time, it critically examines current deviations in practice—such as the decorative, technical, and superficial appreciation approaches—through specific teaching cases. The paper advocates for value-oriented, goal-driven, and student-centered instruction to achieve an organic integration of mathematical culture and digital technology, thus promoting its true integration into classrooms and nurturing students' core competencies.

Keywords: Mathematical Culture; Digital Instruction; Core Competencies; Mathematical Thinking; Classroom Practice

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In the context of current curriculum reform, the educational value of mathematical culture has received more and more attention. The Compulsory Education Mathematics Curriculum Standard (2022 Edition) and the Senior High School Mathematics Curriculum Standard (2017 Edition, 2020 Revision) both clearly put forward the need to pay attention to mathematical culture, and emphasize integrating mathematical elements from Chinese excellent traditional culture into the classroom to enhance students' cultural identity and mathematical literacy. Mathematical culture is not only the accumulation of human mathematical activity achievements but also reflects the deep-seated value of mathematics in historical and social development. With the development of information technology, the digitization of mathematical culture has become an important carrier of classroom teaching, which can vividly present the evolution process and cultural connotation of mathematical knowledge by means of images, animations, multimedia, etc. However, in practice, there are problems of value deviation. For example, some teachers, lacking a deep understanding, only use it to decorate teaching courseware, display interesting materials, or merely focus on technical operations and formal aesthetics, ignoring the transmission of mathematical ideas, methods, and humanistic spirit. Therefore, it is necessary to return to the core value of the digitization of mathematical culture and clarify its deep-seated functions in cultivating students' thinking quality, cultural literacy, historical vision, etc. Teachers should deeply excavate the connotation of mathematical culture, reasonably use digital technology, and realize the organic integration of content and technology, so as to promote the mathematical culture education to truly "enter the classroom, enter the mind, and nourish the soul".

1 The Value of Digitization of Mathematical Culture

Theoretically, in the digital age, the digitization of mathematical culture can vividly and intuitively reproduce the formation of mathematical concepts, ideas, and methods, display the achievements of mathematicians, and vividly reflect the contributions of mathematics in human life, science and technology, and social development in both words and pictures, reflecting the humanistic activities related to mathematics. Digitization makes mathematical culture "come alive", "spread", and "deepen", fully demonstrating the educational value of mathematical culture. Under the background of the new curriculum standards, the educational value of mathematical culture has been continuously highlighted, and the rise of the digitization of mathematical culture is providing a more diverse and efficient realization path for its entry into the classroom. Through digital means, teachers can break through the limitations of time and space, deeply integrate resources, and intuitively present the cultural context and ideological evolution process behind mathematical knowledge, thereby enhancing students' understanding of the essence of mathematics, stimulating their learning interest, and strengthening their core literacy. The following discusses the value embodiment and practical path of the digitization of mathematical culture in teaching from three aspects.

1.1 Intuitively Reconstructing the Development Context of Mathematical Concepts: Breaking through Time and Space Limitations and Rebuilding the Cognitive Structure of "Why Concepts Are Born"

In mathematics teaching, the introduction of concepts is often compressed into a few definitions and examples, making it difficult for students to understand the background and development process of their generation, resulting in students' lack of necessary psychological preparation and sense of identity for the learning of concepts. This phenomenon is particularly common in contents such as "radian system" and "intuitive drawing of cuboid". Due to the limitations of their own knowledge structure, class hours, and other conditions, teachers find it difficult to give a detailed explanation, and students are prone to ask questions like "Why should we learn this concept?".

Digital means provide a feasible path to solve this teaching pain point. For example, when teaching the radian system, teachers can use digital resources to reproduce the problem of unit inconsistency encountered by ancient astronomers in observing the movement of stars, and show the limitations of the angle system in actual measurement. Then, use interactive graphics to demonstrate the whole process of ancient Greek mathematicians defining the radian starting from the unit circle, supplemented by historical documents and character stories, to guide students to understand that the emergence of the radian system is not only the evolution of mathematical tools but also reflects the scientific pursuit of measurement unity and thinking standardization. This can not only answer students' cognitive questions but also help them establish the value recognition that "mathematical concepts have historical and practical significance".

1.2 Dynamically Presenting the Formation Process of Mathematical Ideas: connect the Deep Connection between "Calculation Principles" and "Solution Methods"

The formation process of mathematical ideas is often highly abstract and logical, and due to the limited space in traditional classrooms, it is often simplified into conclusion presentation, so that students only know what it is, but not why it is. This not only weakens the systematicness of mathematical thinking training but also makes it difficult for students to appreciate the charm of mathematical exploration. Digital means can dynamically, continuously, and interactively present the development process of mathematical ideas, helping students deeply understand the essential connection that "solution methods originate from ideas, and ideas are rooted in problems".

1.3 Deeply Showing the Connection between Mathematics and Other Disciplines: Digitalization Helps Cultivate Interdisciplinary Core Literacy

Establishing the connection between mathematics and other disciplines is an important way to improve students' mathematical core literacy, especially application awareness and cultural understanding. In the real world, science, art, engineering, natural phenomena, etc., are full of the shadow of mathematics, and digital technology can concretize and visualize these abstract connections, allowing students to understand the interdisciplinary value of mathematics in immersive experiences.

Taking the connection between mathematics and music as an example, teachers can guide students to find the relationship between temperament and mathematics from the ancient Chinese "three-part profit and loss method". Through digital simulation of the sounding process of the Pitch - pipe unearthed from the Mawangdui Han Tomb, collect the vibration frequency data corresponding to different tube lengths, and use Geometer's Sketchpad to fit the inverse proportional function image, clearly showing the mathematical law of "frequency × length = constant". This process not only allows students to understand how the ancients coordinated temperament in a mathematical way but also enables them to experience the application of function ideas in real problem modeling, expanding the comprehensive value of mathematics in music, history, technology, and other fields.

2 Value Deviation in the Digitization of Mathematical Culture

In the current context of the deep integration of information technology and education, the digitization of mathematical culture, as a new form of teaching resources, is being increasingly introduced into the classroom, aiming to break through the limitations of traditional teaching and promote students' deep understanding of mathematical concepts and cultural identity. However, in the actual teaching process, due to some teachers' insufficient understanding of mathematical culture or improper grasp of the functions of digital means, value deviation phenomena such as "decoration", "technicalization", and "appreciation" have emerged, weakening the educational effectiveness of the digitization of mathematical culture. This paper will analyze the manifestations and causes of these three deviation phenomena combined with specific cases, and put forward improvement directions, in order to better play the value of the digitization of mathematical culture in teaching.

2.1 Decoration of the Digitization of Mathematical Culture: Form Floats on the Surface, Losing Its Inner Teaching Value

Decoration is a more common problem in the application of the digitization of mathematical culture, mainly manifested in that teachers use it as a classroom "beautification" means or interest ，rather than truly designing and integrating it around teaching objectives, resulting in content disconnection and invalid resources.

Aiming at this problem, teachers should be aware that the digitization of mathematical culture should not be a "embellishment" of teaching, but should serve teaching objectives. For example, in the process of teaching frequency estimation probability, digital simulation technology can be used to restore historical random experiments (such as bean throwing experiments, copper coin tossing, etc.), and help students observe the process of frequency gradually tending to stability through a large number of experiment simulations and data accumulation, so as to deepen the understanding of the concept of "frequency approximating probability". Such a design not only retains the situational charm of mathematical culture but also does not deviate from the teaching objectives, truly realizing the two-way integration of "culture" and "teaching".

2.2 Technicalization of the Digitization of Mathematical Culture: Ignoring the Student Subject and Weakening the Thinking Training Process

The deviation of technicalization is reflected in that teachers one-sidedly pursue the beauty and efficiency of technical presentation, use technology to replace students' hands-on exploration and thinking activities, weaken students' active participation and cognitive depth, and lead to the superficiality of teaching effects.

The correct approach should be to make students the main body of learning, with teachers and technology providing support and guidance. For example, when learning fractal graphics, teachers can first design tasks to guide students to carry out manual operations and discover the change rules of the side length and area of the graphics. On this basis, use digital means to assist in displaying the evolution trend and its performance in nature, such as Romanesco broccoli, seahorse tails, snowflake crystals, etc. This not only ensures the complete process of students' inquiry but also deepens the connection between mathematics and nature through technology, improving students' interdisciplinary understanding and application ability.

Digital tools should become "amplifiers of students' thinking", rather than "substitutes for teachers' operations". Teachers should pay attention to guiding students to change from "watching animations" to "understanding principles", avoid the phenomenon of "students watching lively but learning shallowly", and truly play the function of technology to help deep learning.

2.3 Appreciation of the Digitization of Mathematical Culture: Emphasizing "Beauty" over "Essence",

Breaking Away from the Logic of Knowledge Generation

Appreciation is a more hidden value deviation phenomenon, manifested in that teachers display the digital resources of mathematical culture as a "visual feast", but fail to effectively combine with the teaching key points, resulting in students only staying at the perceptual appreciation level, without deep understanding of the essence of mathematical ideas.

The improvement direction should be to organically integrate "mathematical aesthetic education" with "mathematical knowledge", and guide students to go deep from "where the beauty is" to "why it is beautiful". In the teaching of the golden section, teachers can design tasks to guide students to use ruler and compass to construct the golden section line segment and deduce its numerical relationship; further introduce the limit relationship between the Fibonacci sequence and the golden ratio, so that students can understand the universality and rationality of this ratio in nature and engineering design. Then, use Geometer's Sketchpad to dynamically demonstrate the nesting process of the golden rectangle, helping students understand the mathematical foundation of its self-similar structure and aesthetic value, and finally realize the chain-type cultivation of "mathematical culture - knowledge construction - core literacy".

3 Value Realization of the Digitization of Mathematical Culture

Under the guidance of new-era educational concepts, mathematics curricula should not only focus on knowledge transmission but also emphasize cultural education. As the spiritual core of the mathematics discipline, mathematical culture is the crystallization of human wisdom in the development of civilization and an important foundation for enhancing students' mathematical literacy and cultural identity. With the rapid development of digital technology, the dissemination and presentation forms of mathematical culture have ushered in a new revolution. How to deeply excavate the connotation of mathematical culture in the digital context and make it truly integrate into classrooms and serve teaching is an important issue urgently needing solution in current educational practice. The digitization of mathematical culture is not a simple technical display but a process of in-depth integrated teaching design, requiring teachers to continuously explore and innovate in concepts, content, and methods.。

3.1 Tracing the Essence of Concepts to Consolidate the Foundation of Digitized Mathematical Culture

Mathematical concepts carry the logical structure of the mathematical knowledge system and are the core of students' mathematics learning. Many concepts originate from specific problems in early human production and life, and gradually form a complete definition and system through long-term thinking evolution and academic precipitation. When students understand these abstract concepts, they often face huge cognitive challenges. Tracing the development history of concepts through digital means can not only help students overcome cognitive barriers but also guide them to appreciate the historical foundation and humanistic value of mathematical concepts.

Therefore, the digitization of mathematical culture must first be based on in-depth excavation of the origin of mathematical concepts. Teachers should start from questions such as "Where do concepts come from?", "What development have they experienced?", and "What problems have they solved?", and use technical means to reproduce their historical logic and thinking processes, allowing students to grasp the "soul" of mathematics while understanding its "form," thus truly achieving "knowing what it is and why it is so."。

3.2 Grasping Mathematical Ideas to Reflect the Depth of Digitized Mathematical Culture

Mathematics is not only a collection of knowledge but also a crystallization of ideas. Mathematical ideas are the core running through the entire process of mathematics learning and the key for students to form rational thinking and improve problem-solving abilities. In actual teaching, mathematical ideas are often difficult for students to perceive deeply due to their high abstraction and non-intuitiveness. With the help of digital means, teachers can dynamically present the generation process of mathematical ideas, stimulate students' interest in exploration, and guide them to actively construct thinking models, thus achieving the sublimation from "knowledge learning" to "ideological experience."

In these teaching practices, the application of digital means is no longer just "demonstrating knowledge" but becomes a bridge for "transmitting ideas." Through dynamic simulation, interactive experience, and other methods, teachers can concretize and visualize abstract mathematical ideas, enabling students to feel the power of ideas in participation and achieve thinking migration in construction. This is the deepest value embodiment of digitizing mathematical culture.。

3.3 Expanding Mathematical Applications to Broaden the Breadth of Digitized Mathematical Culture

Mathematics is not only a theoretical discipline but also a powerful tool to serve reality and support development. The digitization of mathematical culture should go beyond the vision of "internal mathematics" and expand to the connection between "mathematics and the external world." Constructing interdisciplinary teaching scenarios through digital means and allowing students to experience the application value of mathematics in the real world helps improve their modeling ability, quantitative awareness, and comprehensive literacy.

In addition, in the combination of mathematics and nature, teachers can use tools such as Geometer's Sketchpad or 3D modeling software to construct fractal graphics.The breadth of mathematical applications is not only reflected in the expansion of "application problems" but also in the cognitive expansion at the cultural level. The digitization of mathematical culture should be committed to constructing a three-dimensional teaching model of "intra - disciplinary - inter - disciplinary - extra - disciplinary," allowing students to think about mathematics in a broad vision, understand mathematics in rich cultures, use mathematics in real contexts, and achieve the organic integration of knowledge, ability, and value.

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