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Research on the Innovative Path of Empowering Mathematical Cultural Education with Intangible Cultural Heritage Celadon Art

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Abstract

This paper explores the contemporary mission and practical paths of how intangible cultural heritage celadon art can empower mathematical culture education. Celadon art, as a representative of China's fine traditional culture, is rich in mathematical elements and can effectively promote the cultural educational function in mathematics education. Celadon art integrates mathematical aesthetics, mathematical thinking, and mathematical history in multiple dimensions, enriches the content of mathematics teaching, and helps students improve their abilities in mathematical abstraction, logical reasoning, and cultural identity. This article analyzes the deep integration of celadon art with mathematics education, proposes a four-dimensional teaching model of "cultural perception - mathematical inquiry - innovative application - cultural dissemination" to promote the transformation of mathematics teaching from knowledge-based to cultural education, and initially presents specific strategies and implementation paths for integrating intangible cultural heritage art with mathematics teaching in practice.

Keywords

Intangible cultural heritage celadon, mathematical culture, cultural education, STEAM education, interdisciplinary teaching.

1. Educational Value: The Mission of The Era That Intangible Cultural Heritage Celadon Empowers Mathematical Culture Education

Mathematics is not only a tool for calculation and reasoning, but also a carrier of thought and culture, an important part of human civilization. Teaching mathematics is passing on the culture of mathematics, especially the traditional Chinese culture. Understanding conventional Chinese mathematical culture is not only for learning the mathematical ideas and methods within it but also for gaining cultural confidence in the inheritance process[1]. The culture of mathematics has significant educational value. *The Compulsory Education Mathematics Curriculum Standard (2022 Edition)* proposes that Chinese fine traditional culture should be organically integrated into the mathematics curriculum, with attention paid to the inheritance and promotion of Chinese fine traditional culture[2]. "Mathematics culture" has been incorporated into the core literacy cultivation system, and mathematics education is undergoing a paradigm shift from "knowledge-based" to "culture-based"[3]. Math culture effectively enhances students' abilities in mathematical abstraction, logical reasoning, and cultural identity through the three paths of thought origin, aesthetic experience, and practical application[4]. Celadon art, as an important part of China's fine traditional culture, contains profound cultural connotations. The art of making celadon incorporates mathematical elements such as the symmetry of geometry and the mathematical beauty of proportion, embodying the wisdom of ancient artisans and highlighting the charm of Chinese culture, which is of profound significance for enhancing students' cultural confidence. Mathematical culture and intangible cultural heritage celadon have an inherent consistency in education. The interdisciplinary integration of the two can empower mathematics teaching with intangible

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cultural heritage art, enhance students' innovation ability and cultural confidence, and truly achieve "Foster Virtue and Cultivate Talent".

2. Theoretical Framework: There Is An Inherent Consistency in Education Between Celadon Art and Mathematics Education

2.1. The deep coupling of mathematical culture with the new curriculum standards

The Compulsory Education Mathematics Curriculum Standard (2022 Edition) clearly states that mathematics carries ideas and culture, and requires the organic integration of China's fine traditional culture into the curriculum system. Celadon art, as a typical representative of intangible cultural heritage, its integration of Mathematics education is in line with the core appeal of "Culture-based education" in the new curriculum standards. Mathematical culture achieves its educational function through three dimensions: mathematical aesthetics, mathematical historical context, and mathematical thinking, and celadon art is precisely the embodiment of these dimensions. The new curriculum standards emphasize the orientation of core literacy, and the mathematical elements of Celadon's intangible cultural heritage have a natural fit with the core literacy of mathematics.

The symmetry of celadon patterns corresponds to the geometrical intuition literacy; Fractional calculation of glaze mix intensifies "Computational proficiency literacy"; The line statistics model for kiln temperature control deepens the concept of data analysis. Cultural immersion pedagogy responds to the new curriculum standards' requirement of "enhancing cultural self-confidence" and breaks through the limitations of de-contextualization in traditional mathematics education[5].

2.2. The interdisciplinary education mechanism under the STEAM framework

The integration of celadon art and mathematics education is essentially a typical practice of the STEAM education paradigm. The collaboration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) has facilitated the establishment of a closed-loop mechanism of 'cultural perception → mathematical inquiry → innovative application[6]. Introducing celadon art into mathematics classes can guide students to perceive and appreciate the aesthetic of art, explore the mathematical principles it contains, and promote the improvement of both mathematical thinking and artistic literacy. Empower mathematics learning with art and promote the all-round development of students through interdisciplinary integration. Cultivate students' mathematical thinking, enhance their innovation and hands-on abilities, and promote their all-round development.

3. Intrinsic Foundation: The Aesthetic Value of Celadon Art Itself Is Rich in Mathematical Culture

The depth of the meaning of mathematical culture, mathematical aesthetics, mathematical thinking, and the history of mathematics together constitute the profound foundation of mathematical culture. Celadon art has a profound connection with mathematical aesthetics. The research by Chen Keke and Tang Hengjun reveals the axially symmetrical geometric sequence and densely laid pattern in the lotus petal patterns of Wuzhou Kiln. Sun Hu emphasized the mathematical thinking and geometric aesthetics contained in the ceramic culture[7]. Tong Le, in his research on integrating the study of China's fine traditional culture into mathematics teaching, pointed out the mathematical beauty of symmetry and rotation contained in the "Miaodigou petal pattern" in Yangshao culture, which symbolizes the "flower of China"[8]. The neck and belly ratio of the Southern Song Dynasty Longquan Celadon plum

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green glaze pitcher empirically demonstrates the universality of the golden ratio. Its vessel shape curves implicitly embody a quadratic function model, showcasing the perfect unity of mathematical proportion and artistic beauty[9]. The peony motif on Yuan Dynasty blue-and-white porcelain, through the combination of central symmetry and mirror symmetry, creates a visual effect of 'displaced repetition,' which corroborates the geometric properties that remain invariant under continuous deformation in topology[10]. The phenomenon of such "blending of form and principle" indicates that celadon art is a three-dimensional materialization expression of mathematical aesthetics.

The evolution of celadon art is deeply associated with the development of the history of mathematics. The speed control system of the "pottery chariot" in the Longquan Kiln of the Song Dynasty implies the relationship between angular velocity and centrifugal force. The empirical formula of "a steady speed leads to a round body" in "Tiangong Kaiwu" is in line with the modern calculation principle of π[11]. The process requirement of 'three checks on one clay' in the kiln workers' measurement mnemonic is essentially the practical application of fractions, operations, and proportional distribution.

The algorithmic thinking and model-building ability contained in celadon art are highly consistent with the core literacy of mathematics. Take the proportion of glaze as an example. The iron oxide content of plum celadon needs to be precisely controlled within the range of 2.5%-3.5%. The process of proportioning is essentially an extreme value problem and the solution of the functional relationship[12]. In addition, the Mosaic pattern of celadon and the three-dimensional geometric design of the kiln structure both demonstrate the mathematical thinking traits of spatial imagination and logical reasoning.

4. Practical Foundation: The Integration of Mathematics and Culture in Celadon Art Education Has A Rich Practical Foundation

At present, integrating celadon art into mathematics education practice, promoting students' ability development and moral cultivation with intangible cultural heritage mathematics culture, and fulfilling the mission of "Foster Virtue and Cultivate Talent" is already very extensive. In terms of cultural perception, Zhejiang Normal University has revealed the laws of mathematical aesthetics through geometric analysis of the lotus petal pattern of Wuzhou Kiln[13], and Qingdao Jinmen Road Primary School has achieved a concrete perception of the proportion and function model of the vessel through research and study at the Celadon Museum[14]. Such practices have activated the mathematical elements in the context of intangible cultural heritage and stimulated students' interest in learning, but failed to connect the systematic logic of "skill - culture - mathematics". In terms of mathematical inquiry, fifth-grade students trained their data visualization skills through statistical modeling of the temperature of the Longquan celadon kiln, and Cixi Kuangyan Experimental School transformed the mnemonic of glaze proportioning into fractional operation tasks to achieve practical transformation of mathematical knowledge, but there were still problems such as superficial design and insufficient stimulation of higher-order thinking. In terms of application, the "Celadon Math Workshop" integrates measurement, modeling, AR technology, and artistic creation to enhance students' innovation ability, but the existing practice still has the problem of superficial student participation and shallow integration of disciplines. At the level of cultural dissemination, the intrinsic value of cultural dissemination is hidden in the process of mathematics teaching, achieving the dissemination of mathematics culture imperceptibly and demonstrating cultural confidence, but there are still problems such as ambiguous evaluation criteria in cultural dissemination.

Existing practices have verified the unique value of intangible cultural heritage celadon in mathematical aesthetic perception, knowledge context transformation, interdisciplinary ability

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integration, and cultural identity shaping, providing empirical support for "cultural education". However, there are still bottlenecks such as the fragmentation of cultural element mining, the superficial design of inquiry questions, the formalization of disciplinary integration, and the simplification of evaluation systems.

5. Path Design: Design of a Four-dimensional Teaching Model for Mathematics Education Empowered By Intangible Cultural Heritage Celadon

Based on the theoretical framework and practical foundation, this study proposes a four-in-one practice path of "cultural perception - mathematical inquiry - innovative application - cultural dissemination". By systematically integrating the mathematical cultural genes of Celadon's intangible cultural heritage, it aims to break through the bottlenecks in current practice such as cultural fragmentation, superficial inquiry, formalized integration, and simplistic evaluation, and achieve the coordinated development of mathematical literacy and cultural identity.

5.1. Cultural perception layer: Systematic exploration of mathematical elements in the context of intangible cultural heritage

Reconstruct the context of intangible cultural heritage with a trinity logic of "history - craft - mathematics" to achieve in-depth exploration and structured presentation of mathematical elements. First, physical observation and dynamic restoration: Through the measurement of the geometric features of the celadon of the Southern Song Dynasty teapot, the Yuan Dynasty peony-pattered porcelain shards, and the dynamic restoration of the production process, the application of PI in the pottery wheel shaping is established to establish the associative cognition of "form - number - history" and solve the problem of fragmented cultural perception[15]. Seconds, scenario creation, and symbol decoding: Based on scenarios such as the Celadon Museum and digital twin kilns, develop tasks such as "Decoding the pattern code" and "Exploring the glaze color function", and transform the rotational transformation of the lotus petal pattern and the piecewise functional relationship of the glaze color gradient into interactive mathematical problems.

5.2. Mathematical inquiry layer: Gradient problem chains drive deep learning

With "phenomenon - principle - model" as the logical main line, design a stepwise problem chain to promote the advancement of mathematical thinking from empirical description to model construction. The foundation layer: Through experimental recording and data visualization, the basic skills are consolidated around explicit mathematical problems such as the fraction calculation of glaze mix in celadon production and the line statistics of kiln temperature fluctuations. Advanced level: Guide students to construct mathematical models of complex situations and explore the coupling relationship between solid geometry and physical variables. Advanced level: Deconstructing the mathematical wisdom of ancient craftsmanship through interdisciplinary problems, using finite element analysis software to simulate the stress distribution in celadon firing, and inferring the extreme value optimization logic in the "thick body, thin glaze" design of Song Dynasty craftsmen.

5.3. Innovative application layer: Cross-disciplinary project-based reconstruction empowered by technology

Build a STEAM project loop of "cultural prototypes → mathematical deconstruction → technological reconfiguration" to achieve the integration of disciplines from formalization to depth. Collaborative design of mathematics and engineering: Restore the shape of celadon through 3D printing technology, and verify the quantitative impact of curve equations such as

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parabolas and calculus on the aesthetic appeal of the shape with parametric modeling software[16].

5.4. Cultural dissemination layer: Data-driven socialized evaluation and digital sharing

Establish a three-in-one cultural dissemination mechanism of "quantitative assessment - social feedback - open source resources". Establish a multi-dimensional evaluation system, develop a three-dimensional evaluation scale of "mathematical rigor + artistic expressiveness + cultural dissemination power", and use blockchain technology to trace the social influence data of students' works. This approach enables the transformation of intangible cultural heritage celadon from a "cultural symbol" to an "educational carrier" through systematic decoding of cultural genes, gradient design of thinking advancement, deep integration of technical principles, and ecological construction of evaluation and dissemination.

6. Summary and Outlook: A Summary of the Path of Intangible Cultural heritage Celadon art empowering Mathematical Culture Education

Celadon art empowering mathematics culture teaching, through the four levels of cultural perception, mathematical exploration, innovative application, and cultural dissemination, constructed a systematic path of intangible cultural heritage empowering mathematics culture teaching, proposed new ideas for cultural education, and provided effective references for the integration of China's fine traditional culture into mathematics classrooms. In teaching practice, we can also extend to more types of Chinese excellent traditional culture, delve deeply into the mathematical principles and thinking contained therein, think about their growth points in mathematics teaching, and complete the transformation of educational forms so that Chinese excellent traditional culture can better permeate mathematics classrooms[17].

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