

# The Integration of Cultural Immersion and Mathematics Education—— An Analysis of the New PEP Mathematics Textbooks for Grade 7

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## ABSTRACT

This study examines the newly compiled PEP Mathematics textbooks (Grades 7A & 7B), developed in accordance with the Compulsory Education Mathematics Curriculum Standards (2022 Edition), through 3 dimensions: types of mathematical culture, implementation levels of mathematical culture, and functional roles of mathematical culture in textbooks. The findings reveal that the new textbooks demonstrate positive attempts in integrating mathematics and culture, yet there remains room for improvement in terms of the diversity of cultural types, the depth of historical mathematics applications, and the richness of mathematical culture's pedagogical functions. Based on these findings, specific recommendations are proposed for textbook compilation and instructional strategies.

At the dawn of the 21st century, scholarly inquiry into mathematical culture began to flourish in China, yielding numerous academic achievements in this field. Researchers have profoundly recognized mathematics as a cultural entity possessing educational functions<sup>[1]</sup>. This awakening has revealed mathematics' long-overlooked cultural essence and humanistic dimensions. Consequently, the dissemination and advancement of mathematical culture has become a focal concern for mathematics educators. As an organic component of mathematics curricula, mathematical culture represents an intrinsic requirement of course design. The Compulsory Education Mathematics Curriculum Standards (2022 Edition) (hereafter referred to as the "2022 Standards") explicitly states in its "Curriculum Phi-

losophy" section: "Mathematics curriculum content serves as the crucial vehicle for achieving curricular objectives. The selection of curriculum content should focus on cutting-edge developments in mathematics and mathematical culture, inherit and promote China's excellent traditional culture, while remaining contemporary to reflect the needs of modern science, technology, and social development"<sup>[2]</sup>. Enhancing mathematical cultural literacy and integrating mathematical culture into pedagogy have thus become essential professional requirements for mathematics teachers. Moreover, the explicit requirements regarding mathematical culture in junior secondary mathematics examination syllabi have compelled particular attention from schoolteachers. However, mathematical culture in

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examinations often merely serves as superficial “labeling,” resulting in the paradoxical situation of “high evaluation but low application” in primary and secondary education. Exemplary cases of effectively integrating mathematical culture into mathematics instruction remain scarce, and the pedagogical value inherent in mathematical culture has not been fully realized in practice. This stems primarily from three factors: insufficient understanding of the conceptual dimensions of mathematical culture, a lack of teachable mathematical cultural resources, and limited knowledge regarding implementation approaches and proficiency levels for such materials [3].

Existing domestic literature has extensively examined mathematical culture in textbooks from China, France, Australia, and the United States, aiming to provide recommendations for improving Chinese mathematics textbooks. Nevertheless, most studies remain constrained by established analytical frameworks. Addressing this limitation, the present study synthesizes multiple frameworks proposed by scholars worldwide for analyzing mathematical culture in textbooks, seeking to more precisely interpret cultural connotations in mathematics instructional materials and provide theoretical foundations for subsequent research.

In response to the 2022 Standards under the new curriculum reform, the People’s Education Press has revised the Grade 7 mathematics textbooks (hereafter “new textbooks”), implemented in autumn 2024 and spring 2025 respectively. This study employs mathematical culture research frameworks to conduct data analysis of these new textbooks, investigating: (1) what types of mathematical culture are incorporated, (2) the purposes of such cultural elements, and (3) the methodologies of cultural integration. The findings aim to enhance teachers’ textbook com-

prehension and instructional decision-making, ultimately optimizing teaching strategies and improving educational quality.

### 1.Comprehensive Analytical Framework for Mathematical Culture in Mathematics Text-books

Tang Hengjun et al. proposed analyzing mathematical culture from 3 dimensions: the types of mathematical culture, their implementation levels in textbooks, and their functional roles [4]. Regarding cultural typology, Wang Xiaoqin initially classified mathematical culture into 6 categories: history of mathematics, mathematics and daily life, mathematics and science, mathematics and humanities, mathematics and art, and recreational mathematics [5], which were later consolidated into four broader categories: history of mathematics, mathematics and daily life, mathematics and science/technology, and mathematics and humanities/art [6]. Other scholars have developed alternative classification systems: Li Zhuochen categorized mathematical culture into knowledge origins, interdisciplinary connections, social applications, aesthetic entertainment, and multicultural perspectives, with each major category containing multiple subcategories [1]; while Liu Fang proposed 5 types: historical mathematical materials, mathematics and other disciplines, mathematics and real-life applications, mathematics and modern information technology, and mathematical games [7]. Building upon these foundational studies, this paper operationalizes mathematical culture in textbooks as comprising 5 types: history of mathematics, interdisciplinary connections, social roles, aesthetic entertainment, and multicultural perspectives, with detailed conceptual definitions provided in Table 1.

**Table 1:** Conceptual Definitions of 5 Categories of Mathematical Culture

Category	Definition and Subcategories
History of Mathematics	Refers to historical mathematical materials. Subcategories include: concepts, propositions, symbols, tools, thought, methods, and terminology; as well as mathematicians’ biographies and related historical anecdotes.
Interdisciplinary Connections	Refers to the connections between mathematics and other disciplines. Divided into two subcategories: (1) Science & Technology: earth sciences, biology, physical sciences, high technologies, architectural sciences; (2) Humanities & Arts: humanities, fine arts, architectural arts.
Social Roles	Refers to the relationship between mathematics and real-life applications. Subcategories include: daily life, school life, recreational activities, social life, professional life, and economic life.
Aesthetic & Recreational Aspects	Comprises mathematical aesthetics and recreational mathematics. Mathematical aesthetics primarily includes simplicity, harmony, and symmetry as manifestations of beauty. Recreational mathematics encompasses mathematical riddles, games, and puzzles.
Multicultural Perspectives	Emphasizes the influence of diverse regional cultural contexts. Divided into two types: (1) Creative (theoretical/cultural development); (2) Applied (practical implementation across cultures).

Wang Jianpan, Wang Xiaoqin, and other scholars have developed an analytical framework for assessing the implementation levels of mathematical culture, which is categorized into 2 dimensions: the application of history of mathematics and other forms of mathematical culture<sup>[8][9]</sup>. Specifically, the implementation levels of history of mathematics progress through 4 hierarchical stages from superficial to profound: the appendage style (superficial addition without integration), reproduction style (direct copying of historical materials), adaptation style (contextual adjustment to curriculum), and reconstruction style (substantive reintegration into mathematical concepts), as detailed in Table 2. Regarding other types of mathematical culture, 3 distinct implementation levels are identified: (1) external type, where mathematical culture is presented in isolation without connecting to mathematical knowledge or problem-solving; (2) internally separable type, where cultural elements serve as decorative contexts for mathematical problems that remain solvable without the cultural framework; and (3) internally inseparable type, where cultural content becomes an organic component of mathe-

tical problems, requiring the application of mathematical knowledge to address culturally embedded issues, thus forming an indivisible unity between mathematics and its cultural context<sup>[8]</sup>.

Dickenson-Jones proposed 5 transformation approaches for mathematical culture in textbooks: segregation, paraphrase, integration, correlation, and unification, based on which a concentric circle model was constructed<sup>[10]</sup>. Building upon the research frameworks established by both Dickenson-Jones and Zhang Weizhong et al., this study identifies 5 functions of mathematical culture in textbooks as presented in Table 3<sup>[10][4]</sup>.

Additionally, in cases where a cultural element appears across multiple activities or where multiple categories of cultural elements coexist within a single activity, each instance is counted separately. For statistical purposes, given the substantial volume of exercises, mathematical cultural elements in practice problems are analyzed independently: non-example exercises containing mathematical culture are coded as NE, while those in worked examples are coded as E.

**Table 2:** 4 Implementation Levels of History of Mathematics in Textbooks

Level	Definition and Characteristics
Appendage Style	Isolated visual elements (e.g., mathematical patterns, portraits of mathematicians, theme-related images) or textual supplements (e.g., historical origins of concepts/notations, classical problems, mathematicians' biographies, or ancient methodologies). These elements can be removed without affecting core instructional content.
Reproduction Style	Direct adoption of historical mathematical concepts/terminology, propositions with their original proofs, or classical problems with their authentic solutions.
Adaptation Style	Pedagogically modified historical materials, including: (1) educationally adapted classical problems/methodologies, or (2) historically inspired problem scenarios specifically designed for modern classrooms.
Reconstruction Style	Epistemological reconstruction of knowledge development through "historical-logical-cognitive" integration, presenting target knowledge via genetic approaches that mirror its historical emergence.

**Table 3:** Five Functional Roles of Mathematical Culture in Textbooks

Category	Connotation and Implementation Characteristics
Providing Contextual Background	Offers cultural materials as learning contexts without requiring students' active engagement in these contexts for mathematical learning.
Creating Applicative Contexts	Requires student participation in cultural practices to recognize mathematics' utility, but does not emphasize knowledge construction across cultures.
Expanding Mathematical Thinking	Encourages comparative analysis of diverse mathematical cultures at theoretical and operational levels, aiming to broaden and deepen students' mathematical cognition and perspectives.
Facilitating Mathematics-Culture Integration	Students acquire mathematical knowledge through cultural experiences while establishing connections between mathematical concepts and cultural practices.
Experiencing Cultural Practices	Demands full immersion in authentic cultural practices (with at least partial adherence to original forms), primarily serving cultural appreciation rather than mathematical learning objectives.

## 2. Analysis of Mathematical Culture in the New Textbook Series

The newly revised People's Education Press seventh-grade mathematics textbooks (Volumes 1 and 2) contain 12 chapters: Rational Numbers, Operations with

Rational Numbers, Algebraic Expressions, Addition and Subtraction of Polynomials, Linear Equations in One Variable, Basic Geometric Figures, Intersecting and Parallel Lines, Real Numbers, Plane Rectangular Coordinate System, Systems of Linear Equations in Two Variables, Ine-

qualities and Systems of Inequalities, and Data Collection, Organization, and Description. Our analysis identified 471 instances of mathematical cultural elements throughout the textbooks, with 119 appearing in NE and 352 in E. As shown in Figure 1, which demonstrates the proportional distribution of mathematical cultural elements between E and NE, the new textbook shows a clear emphasis on integrating mathematical culture into E rather than NE. This approach provides students with systematic opportunities to connect mathematical knowledge with real-world applications and cultural backgrounds through guided problem-solving, thereby enhancing their ability to apply mathematics in meaningful contexts.

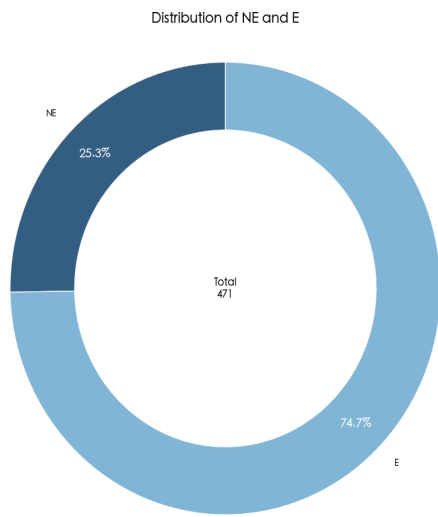


Figure 1

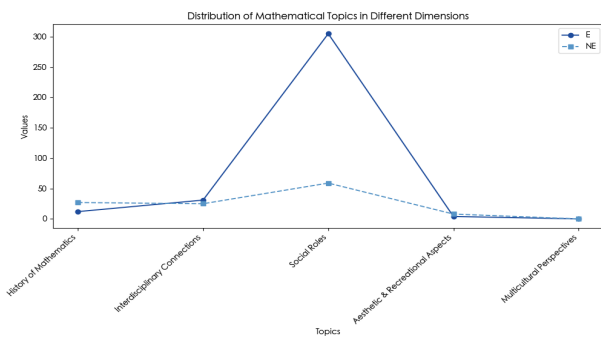


Figure 2

### 2.1 Categories of Mathematical Culture

Mathematical culture is classified into 5 distinct categories. The historical dimension of mathematics reveals the developmental trajectory of mathematical knowledge, where understanding the origins and evolution of mathematical concepts facilitates mastery of the subject

and grasping its essence. Interdisciplinary connections enhance students’ ability to observe the world through a mathematical lens while discovering the intricate relationships between mathematics and the broader world, thereby stimulating interest in mathematical learning. Mathematics not only drives social development but also profoundly advances socio-cultural progress; conversely, society and its culture enrich the mathematical realm. Recognizing mathematics’ applied value in daily life, as well as its recreational and aesthetic dimensions, significantly promotes mathematical learning. Multicultural mathematics primarily comprises historical achievements and cultural applications – two aspects that are mutually independent yet organically integrated, collectively constituting the vibrant tapestry of mathematical culture. The appropriate incorporation of these 5 categories in mathematics textbooks holds significant implications for both teacher professional development and talent cultivation.

Figure 2 presents a line graph illustrating the quantitative distribution of mathematical culture types in E and NE sections. Overall, social roles and interdisciplinary connections emerge as the most prevalent types of mathematical culture. In NE sections, the textbook primarily utilizes social roles and interdisciplinary connections to construct contextual backgrounds for knowledge acquisition. The E sections show particularly prominent frequency of social roles as problem contexts, reaching 305 instances. Notably, multicultural elements are entirely absent throughout the textbooks, with only minimal instances of aesthetic-recreational culture appearing in Volume 2.

### 2.2 Implementation Levels of Mathematical Culture

The implementation levels of mathematical culture are primarily categorized into 2 types: the application level of history of mathematics and the application level of other forms of mathematical culture. As the implementation level increases in sophistication, the difficulty of integration grows correspondingly, while its educational value becomes more significant.

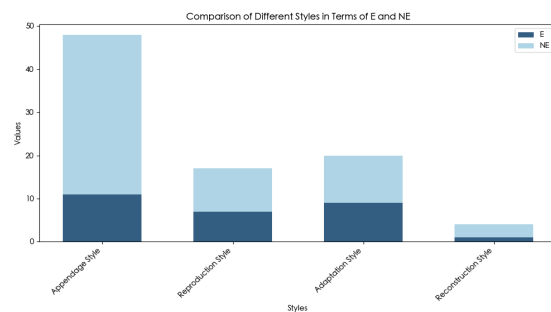


Figure 3

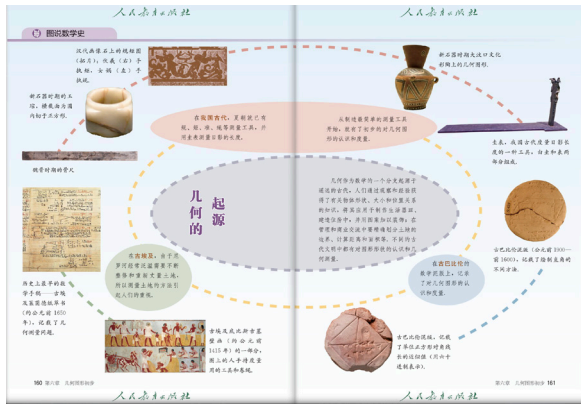


Figure 4: "Illustrated History of Mathematics" section

Figure 3 presents the statistical distribution of implementation levels for history-related content in E and NE sections of the new textbook. The data clearly shows that in NE sections, the appendage style predominates in the application of mathematical history. This reflects a major innovation in the textbook's compilation - the addition of "Illustrated History of Mathematics" and "Tracing Origins" sections (Figures 4 and 5) within the mathematical content. As these sections primarily serve as supplementary reading materials, the relatively basic level of historical application is understandable. In E sections, while the appendage style remains dominant, both the adaptation style and reproduction style appear with greater frequency. By integrating historical materials with mathematical problems, these implementation levels effectively realize the application of mathematical history, aligning well with the applied nature of worked examples and exercises. Figure 6 demonstrates a typical "reproduction style" example, directly adopting a historical mathematical problem. Figure 7 illustrates the "adaptation style," where a historical problem has been pedagogically modified to better suit contemporary classroom teaching.

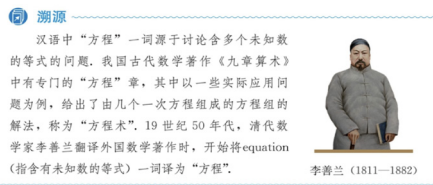


Figure 5: "Tracing Origins" section

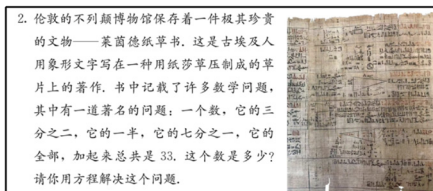


Figure 6

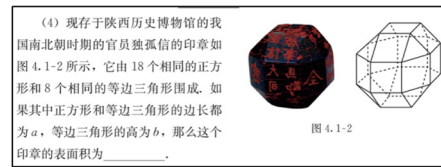


Figure 7

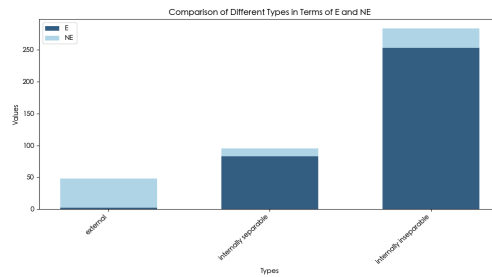


Figure 8

Figure 8 displays the statistical distribution of implementation levels for other forms of mathematical culture. Overall, the "internally inseparable type" appears most frequently, followed by the "internally separable type," with the "external type" being least common. In E sections, the predominance of the "internally inseparable type" indicates that mathematical culture forms an organic component of mathematical problems, where cultural elements are inextricably linked to problem-solving and mathematical knowledge. Conversely, in NE sections, other forms of mathematical culture mainly manifest as the "external type," where the connection between cultural elements and new knowledge remains peripheral and less substantial.

### 2.3 Functions of Mathematical Culture in Textbook Integration

Research on the functions of mathematical culture in textbooks provides teachers with innovative perspectives and instructional approaches, enabling them to deeply explore the cultural connotations and educational values embedded in teaching materials. This ultimately enhances teaching quality and constructs culturally-rich mathematics learning experiences for students, promoting the coordinated development of both knowledge competencies and cultural literacy.

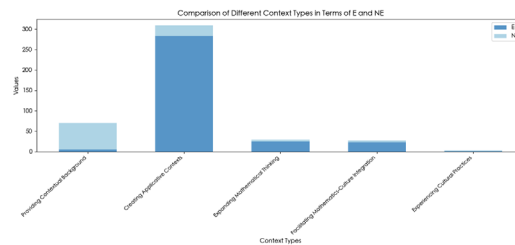


Figure 9

As revealed in Figure 9, the textbook primarily positions mathematical culture to serve 2 functions: providing applicative contexts and background contexts. In the E sections, the core mission of mathematical culture focuses on constructing applicative contexts, aiming to guide students in integrating abstract mathematical knowledge into practical problem-solving, thereby strengthening their practical operational skills and applied thinking. In contrast, the NE sections emphasize using mathematical culture to establish background contexts for learning. This approach helps students thoroughly comprehend the origins, evolutionary processes, and cultural significance of mathematical knowledge, consequently igniting their learning motivation. Particularly noteworthy is the current textbook's insufficient representation of the crucial "cultural practice experience" function, which requires urgent reinforcement and greater prominence in future editions.

### **3 Suggestions for Textbook Compilation and Instructional Practice**

The evolving times are reshaping the mission of textbooks, renewing their content philosophy, and challenging their core values. Mathematical culture embodies both "national spirit" and "contemporary imperatives," containing opportunities to enhance students' national identity and potentials to develop core competencies. It therefore stands as a crucial foundation for implementing the fundamental educational task of fostering virtue through mathematics education, and serves as a vital growth point for textbooks to fulfill their educational function<sup>[11]</sup>.

As the convergence point of culture, curriculum documents, and implementation, mathematics textbooks demand thorough analysis, research, evaluation, and development. Being the primary vehicle of teaching activities, textbook quality significantly impacts both instructional effectiveness and student learning outcomes. While the new edition has made remarkable progress in organizing mathematical cultural content, several areas still require improvement. This current situation not only demands continuous refinement from textbook compilers but also provides professional space for teachers to exercise their pedagogical agency.

#### **3.1 Textbook Compilation Recommendations**

##### ***3.1.1 Harmonious Integration of Multicultural Elements for Shared Mathematical Wisdom***

Textbook development should prioritize establishing a balanced multicultural mathematical system by systematically incorporating diverse mathematical cultural materials to achieve profound cultural infusion. At the multicul-

tural level, emphasis should be placed on both excavating unique mathematical wisdom embedded in various ethnic production practices and skillfully interpreting mathematical concepts through cross-cultural perspectives. By demonstrating the developmental trajectories and application scenarios of mathematical knowledge across different civilizations, students can appreciate mathematics' universality as a common human language while understanding its diverse manifestations in various cultural contexts.

On the aesthetic and recreational dimension, mathematical elements from art, music, and games should be artfully integrated to reveal mathematics' intrinsic aesthetic qualities and playful aspects, thereby stimulating students' learning interest. This organic multicultural synthesis not only effectively expands students' mathematical cultural horizons but also deepens their understanding of mathematics' essence, ultimately achieving the unified goals of cultural heritage preservation and disciplinary competency cultivation.

##### ***3.1.2 Dynamic Application of Historical Contexts for Rediscovering Mathematical Thinking***

Textbook compilers should optimize the use of "Illustrated History of Mathematics" and "Tracing Origins" sections by transforming them from simple informational supplements into in-depth teaching resources. Rather than merely presenting historical facts superficially, these sections should achieve organic integration between mathematical history and new knowledge instruction through: (1) systematically organizing conceptual developmental trajectories and reconstructing historical materials using scaffolded problem chains to build progressive cognitive frameworks for students; and (2) recreating mathematicians' problem-solving thought processes to allow students to experience the evolution of mathematical concepts in authentic historical contexts, thereby facilitating active knowledge construction and "rediscovery." This profound historical integration serves multiple purposes: it liberates historical mathematical materials from simplistic appendage-style applications; enhances students' understanding of mathematics' fundamental nature; cultivates historical thinking and innovative awareness; and ultimately maximizes the educational value of mathematical culture.

##### ***3.1.3 Refined Construction of Functional Systems for Comprehensive Enhancement of Cultural Literacy***

Textbook compilers should systematically develop a multifunctional system for mathematical cultural projects that integrates the fundamental functions of providing contextual and applicative scenarios while achieving

organic unity among cognitive expansion, cultural integration, and practical experience. This systematic design involves 3 key dimensions: (1) building upon existing contextual functions by incorporating specialized comparative analysis tasks that guide students to explore mathematical thinking methods across different cultural backgrounds, thereby deepening their methodological awareness and cross-cultural understanding; (2) designing integrated practical activities that enable students to establish profound connections between mathematical knowledge and cultural practices in authentic contexts, facilitating meaningful knowledge construction; and (3) developing experiential projects that maintain fidelity to original cultural forms while balancing the dual demands of cultural appreciation and mathematical reasoning. Such a comprehensive functional architecture not only fully leverages the foundational roles of contextual and applicative scenarios but also broadens students' intellectual horizons and cultivates their cultural literacy, ultimately transforming mathematical cultural projects into crucial bridges connecting disciplinary learning with humanistic cultivation and providing multidimensional support for students' holistic development.

## **3.2 Instructional Recommendations for Teachers**

### ***3.2.1 Cultivating Cultural Foundations for Multidimensional Wisdom Integration***

Teachers should emphasize the multidimensional integration of mathematical culture throughout the instructional process, which fundamentally requires embracing lifelong learning to actively expand knowledge reserves in mathematical history, multicultural studies, and aesthetic applications. Addressing the current textbook's relatively singular focus on social roles and interdisciplinary connections, teachers can enrich their cultural literacy through sustained professional development: systematically studying the historical development of mathematics across civilizations to deeply understand diverse mathematical wisdom; extensively exploring cross-cultural mathematical materials to cultivate multicultural perspectives; and enhancing mathematical aesthetic appreciation to master application principles in arts and music. Only with this comprehensive knowledge framework can teachers effectively incorporate multicultural elements into teaching practice—for instance, by designing localized contexts that connect mathematical concepts with regional history, folk traditions, or economic development to create geographically distinctive mathematical problems. This professional-development-based multidimensional integration approach not only strengthens students' cultural

identity but also develops their capacity for multifaceted mathematical cultural understanding, ultimately achieving balanced development in mathematical cultural education.

### ***3.2.2 Historical Material Reconstruction to Inspire Thinking and Cultural Integration for Knowledge Innovation***

Currently, the application of mathematical history remains predominantly appendage-style. Teachers can build upon historical materials presented in textbooks by supplementing relevant historical resources and re-designing instructional activities to facilitate a transition from simple appendage-style usage to reproduction-style reenactment, adaptation-style transfer, and ultimately reconstruction-style innovation. This transformative process enables students to grasp the developmental trajectory of mathematical thinking through historical contexts, incorporating historical dimensions into knowledge construction to deepen understanding and expand cognitive horizons<sup>[5]</sup>. Addressing the current situation where mathematical culture in non-example exercises mostly remains at the external level, teachers should enhance its integration with mathematical knowledge by: (1) utilizing cultural materials as contextual carriers for problems, allowing students to encounter cultural backgrounds while solving problems; and (2) more importantly, designing “intrinsically inseparable” instruction that makes cultural content an organic component of mathematical problems, requiring cultural context for complete investigation. This transformation strategy demands that teachers both analyze the mathematical essence of cultural materials and design effective connections between contexts and problems, achieving cultural immersion in knowledge transmission while enhancing students' mathematical literacy and cultural comprehension.

### ***3.2.3 Functional Expansion Linking Practice with Subtle Cultivation of Competencies***

Mathematical culture in textbooks should not be limited to providing background or applied contexts, but should further enhance its educational value by functioning as a critical nexus integrating mathematical thinking, cultural comprehension, and applied problem-solving skills. Teachers can achieve this through 3 key approaches: (1) guiding students to explore the cognitive methods underlying mathematical culture, such as analyzing the evolutionary logic of mathematical concepts through historical developmental trajectories, thereby cultivating critical thinking and innovative awareness; (2) actively creating interactive platforms including lectures and discussions to facilitate students' profound understanding and internalization of mathematical culture, strengthen-

ing their cultural identity and practical abilities; and (3) emphasizing organic integration between mathematical culture and real-life situations by directing students to employ mathematical tools in analyzing cultural phenomena, enabling mutual reinforcement between cultural learning and problem-solving. Most crucially, teachers should encourage students to actively construct their understanding of mathematical culture through creative expression, transforming them from passive knowledge recipients into engaged cultural participants, thus holistically enhancing their mathematical literacy and cultural insight. This multidimensional functional expansion not only surpasses the predetermined models in textbooks but also establishes more profound pathways for mathematical cultural education, ultimately realizing the synergistic development of mathematical instruction and cultural immersion.

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