

Evolution and Trends in Research on Mathematical Culture and History: An Analysis Based on Core Journals from CNKI

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Abstract: Mathematical history and culture contain profound educational value, serving as vital educational content for implementing the fundamental task of fostering virtue through education. Utilizing CiteSpace software, this study conducts a bibliometric analysis of literature on mathematical history and culture from core journals in the China National Knowledge Infrastructure (CNKI) database. The findings reveal a consistent upward trend in annual publications within this research field, with normal universities as the primary contributing institutions. Key literature analysis indicates that research themes center on theoretical foundations, mathematics teaching and learning, and multicultural perspectives. Keyword emergence analysis demonstrates that “classroom teaching” “disciplinary integration” and “educative value” have become prominent research foci in recent years. However, theoretical research on mathematics education psychology, interdisciplinary pedagogy, and assessment remains limited, warranting further investigation. Additionally, enhanced collaboration with frontline teachers is recommended.

Keywords: Mathematical Culture, History of Mathematics, Secondary Education, Citespace

1. Introduction

Mathematical history and culture possess profound educative value. They not only stimulate students' interest in learning mathematics and foster their mathematical ethos, but also provide spiritual nourishment for personal growth and offer historical references for understanding cognitive development, while simultaneously guiding and optimizing classroom instruction for teachers^[1]. Serving as a bridge between mathematics and the humanities, mathematical history and culture are vital carriers for cultivating students' core mathematical literacy. Although research on mathematical history and culture has traditionally belonged to distinct thematic domains, they remain intricately linked in mathematics education. For instance, studies on developing mathematical cultural resources frequently draw upon historical materials as essential sources, while research on integrating mathematical history into education inherently addresses the pedagogical value of mathematical culture. Therefore, this study jointly examines mathematical history and culture as research subjects. Using CiteSpace knowledge mapping analysis, we systematically analyze literature from core journals in the CNKI database to trace evolutionary trajectories and dynamic trends in these fields.

2. Research Design

First, Research Subjects. The study selected academic journals from the CNKI database. To ensure comprehensive coverage, an advanced search was conducted with the subject terms “mathematical history” OR “mathematical culture”, covering all publications up to December 31, 2023. Source categories were limited to PKU Core Journals and CSSCI. From the initial results, literature within the secondary education discipline was identified. Titles and abstracts were manually screened to exclude non-research materials. After full-text review focusing on mathematical history and culture relevance, 446 eligible publications were finalized. Second, Research Methodology. The study employed CiteSpace-based knowledge mapping analysis. Third, Research Dimensions. Four analytical dimensions were applied using scientific knowledge mapping: Overall publication trends, Distribution of core institutions and authors, Keyword clustering, Keyword emergence detection. This approach enables real-time retrospective analysis and prospective tracking of research hotspots, revealing disciplinary

trajectories, characteristics, and patterns while empowering scholars to grasp evolving dynamics and future directions.

3. Distribution Characteristics of Literature

3.1 Analysis of Overall Publication Trends

As shown in Figure 1, the annual number of publications on the history of mathematics and mathematical culture in CNKI core journals remained below four articles prior to 2002. A sustained upward trend emerged from 2003 onward, likely attributed to the heightened scholarly attention following the International Congress of Mathematicians held in Beijing on August 20, 2002. Publication volumes peaked in 2011 and 2017, with an average annual output of 14.4 articles over the 31-year period.

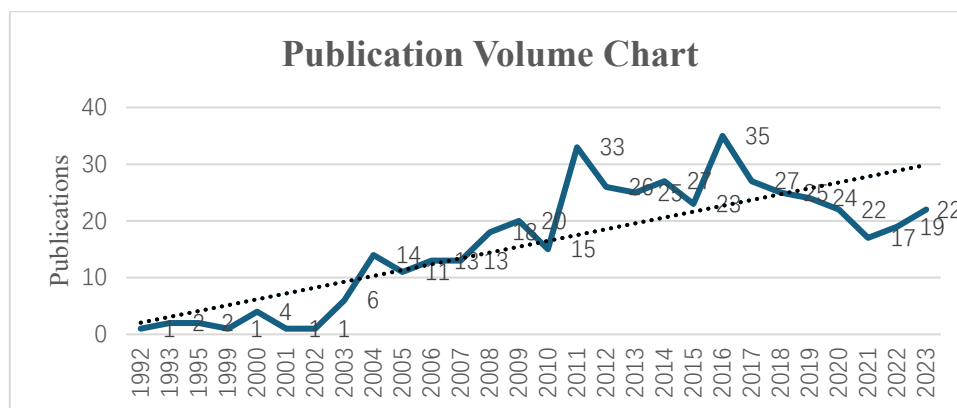


Figure 1 Distribution of Publication Volume

Research on mathematical culture and history experienced significant surges in publication volume during the years of new curriculum standard releases (2011 and 2017). This indicates that the implementation of the new curriculum reform has substantially propelled both theoretical and practical advancements in mathematical culture studies. Prior to the reform, mathematical culture remained largely overlooked by researchers. Following the reform, it gained explicit recognition in mathematics curriculum standards, manifested in textbooks, and became implemented in teaching practices—consequently emerging as a focal point of academic inquiry.

3.2 Distribution of Core Authors and Institutions

Among authors, the top 10 most prolific researchers are Wang Xiaojin, Zhang Weizhong, Dai Qin, Yu Ping, Wu Jun, Li Chunlan, Song Naiqing, Tang Hengjun, Luo Yongchao, Wu Libao. These scholars—recognized as academic leaders in mathematics education—demonstrate robust research engagement in mathematical culture and history. Their sustained collaborative networks reflect a dynamic scholarly ecosystem that significantly advances mathematics education research and wields substantial influence in the discipline.

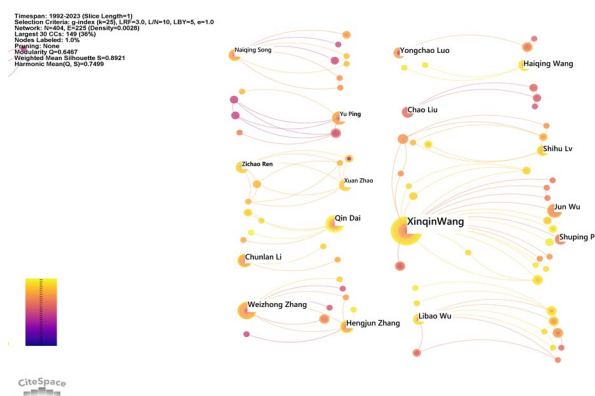


Figure 2 Co-occurrence Network of Core Authors

Regarding institutional distribution (Figure 2), research entities are widely dispersed. Leading contributors include: East China Normal University, Beijing Normal University, Inner Mongolia Normal University, Southwest University, Zhejiang Normal University, Central China Normal University, Nanjing Normal University, Northeast Normal University, Northwest Normal University, Guangzhou University, Shaanxi Normal University, and South China Normal University—predominantly normal universities. These core institutions produced 200 publications, accounting for 44.7% of the total output, establishing themselves as pivotal knowledge producers in mathematical history and culture research.

This pattern reflects four critical issues (Figure 3): First, a disconnect between theory and practice exists. Second, K-12 educators show limited engagement in mathematical culture research, resulting in minimal academic contributions. Third, schoolteachers face constrained academic research capacity. Fourth, while intra-institutional collaboration thrives, such synergy remains localized rather than bridging the school-university divide.

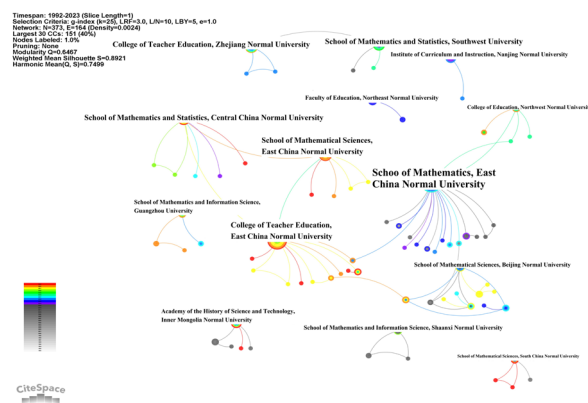


Figure 3 Distribution of Publications by Core Institutions

4. Hotspot Themes in Mathematical History and Culture Research

Keywords encapsulate core themes and their interrelations within the literature. Analyzing them reveals research hotspots. Figure 4 presents the keyword clustering map generated by the software. The clusters exhibit significant modularity and high internal homogeneity, confirming result reliability (Modularity $Q = 0.6467 > 0.3$, Silhouette $S = 0.8921 > 0.7$). Based on clustering outcomes and literature synthesis, major clusters were selected and merged where appropriate. This identified three primary research themes: Theoretical Foundations (Clusters #0, #1, #2, #9), Curriculum and Teaching (Clusters #3, #4, #5, #6, #8, #10), Multicultural Perspectives (Clusters #7, #11).

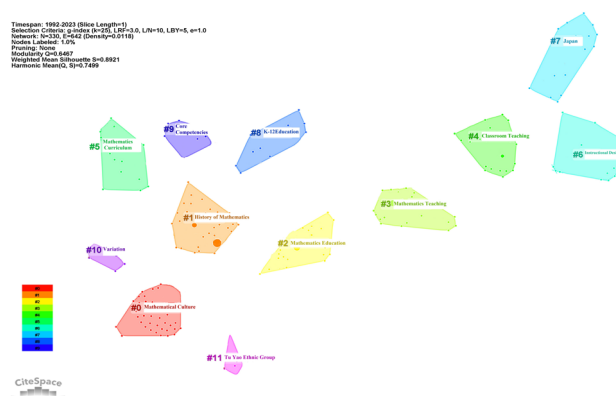


Figure 4 Keyword Clustering Map

4.1 Theoretical Research

Clusters #0 (Mathematical Culture), #1 (History of Mathematics), and #2 (Mathematics Education) represent core theoretical investigations. These explore the connotations of mathematical culture through disciplinary objects and evolution, and examine its extensions by analyzing the cultural and social

significance of mathematical history and culture for education. This theme addresses both the essence of mathematics and pragmatic reflections on educational practice.

4.2 Curriculum and Teaching

Research systematically explores curriculum resource development, pedagogical strategies, teacher education, practical challenges, and educative value.

4.2.1 Curriculum Resource Development

Resources derive from three sources: mathematical history, Chinese traditional culture, and mathematician legacies. Historical elements reveal design philosophies via textbook illustrations and cross-national comparisons, while studies on mathematician ethos remain limited. Content centers on calculus, conic sections, and the Pythagorean theorem, with cases like the evolution of function concepts and historical development of spherical volume formulas.

4.2.2 Pedagogical Strategies

Wang Xiaoqin proposed four HPM integration methods: appending, replicating, adapting, and reconstructing^[2]. Reconstruction—a high-level approach—organically connects knowledge across historical periods, enabling students to experience knowledge genesis and reshape mathematical perspectives, yet remains underutilized. Practical models include fragment-based and problem-contextualized approaches. Junior high teaching emphasizes cultural context creation and textbook resource mining, while Li Hongting established an integrated “textbook-teaching-teacher education-Chinese HPM system” pathway^[3].

4.2.3 Teacher Education

Teachers exhibit knowledge-action gaps: while recognizing cultural value, they often misunderstand connotations and misuse historical materials. Integrating mathematical culture into core teacher competencies is essential. Gu Pei demonstrated that university elective courses effectively enhance preservice teachers’ literacy^[4]. Liu Jiemin identified critical classroom issues: incoherent material selection, disconnection between cultural content and core knowledge, superficial labeling of mathematical thinking, and inaccurate historical references^[5], necessitating intensified practical training.

4.2.4 Educative Value

Scholarly consensus confirms mathematical history and culture as the essence of literacy education—unifying truth, goodness, and beauty. They function to: shape mathematical worldview and cultural identity, cultivate rational thinking and national identity, and ultimately foster patriotism and mathematical literacy. Realizing this value requires scaling reconstructed teaching and systematizing teacher skill development.

4.3 Multicultural Mathematics

Multicultural mathematics refers to the dynamic interplay where diverse cultures generate varied mathematical systems, which in turn adapt to and foster cultural pluralism. It encompasses mathematical knowledge produced and utilized across distinct cultural communities, representing an advancement of ethnomathematics. Grounded in traditional cultures and everyday mathematics, this framework holds significant educational value: it promotes the excavation and preservation of cultural heritage, restores the authentic historical narrative of mathematics, and cultivates citizens with rational thinking and cross-cultural competencies. Crucially, it advocates for recognizing the equality and legitimacy of all cultural mathematical traditions^[6].

Implementation relies on culturally responsive pedagogy, which requires teachers to integrate cultural contexts, cognitive styles, and value systems into mathematical instruction. By embedding learning within culturally meaningful frameworks, this approach bridges academic achievement gaps among diverse ethnic groups. China's multi-ethnic cultural diversity constitutes a rich reservoir for mathematics education. Research on ethnomathematical pedagogical principles offers key paradigms for dismantling educational homogenization and advancing equity.

5. Analysis of Research Trends

Top 25 Keywords with the Strongest Citation Bursts

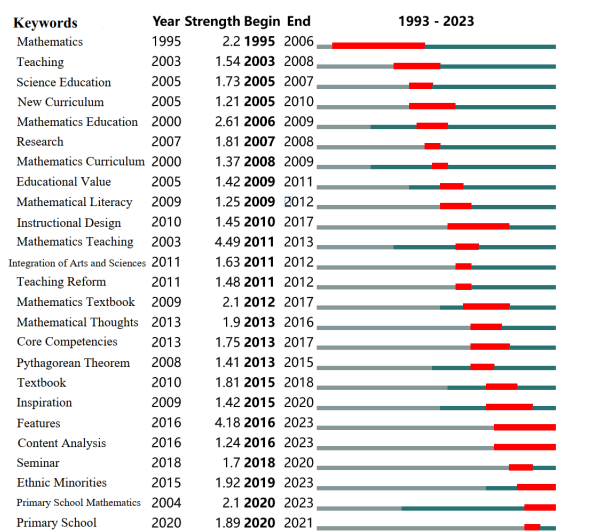


Figure 5 Keyword Burst Map

Burst terms—keywords exhibiting sharp frequency increases within short periods—indicate emerging research frontiers. CiteSpace burst analysis identified prominent themes in mathematical culture research with corresponding burst strengths (Figure 5). After merging synonymous terms, the top 8 burst keywords are: Mathematics Education, Mathematics Teaching, Core Competencies, Primary School Mathematics, Mathematics Textbooks, Ethnic Minorities, Science Education, Mathematical Thinking. Pre-2011: Bursts centered on mathematics education, mathematics teaching, science education, mathematics curriculum, and educational value—reflecting theoretical foundations. 2011-2017: Shifts toward mathematics textbooks, mathematical thinking, and instructional reform—marking a phase of parallel theoretical and applied research with increasing emphasis on practice. Post-2017: Dominance of core competencies, content analysis, ethnic minorities, and primary school mathematics—signaling alignment with new curriculum standards and focus on multicultural contexts and classroom implementation. This trajectory demonstrates evolution from theoretical exploration to practice-oriented innovation, with recent concentration on competency-based frameworks and cultural diversity.

6. Conclusions and Recommendations

6.1 Conclusions

Bibliometric analysis of mathematical culture literature from CNKI core journals reveals three key findings: Publication Growth: Annual output shows a sustained upward trajectory, with normal universities as primary contributors. Thematic Clusters: Research concentrates on theoretical foundations, curriculum, and multicultural perspectives. Knowledge Gaps: Limited attention to mathematics education psychology, competency formation, and evaluation frameworks.

Theoretical Research. Studies predominantly address connotations and values of mathematical culture, establishing multi-perspective definitions and pedagogical significance. However, critical gaps persist in mathematics education psychology and core competency development.

Curriculum and Teaching. Integration focuses on content selection, pedagogical strategies, and teacher education. A notable absence is evaluation research on classroom implementation effectiveness.

Multicultural Dimensions. Research explores multicultural mathematics, ethnomathematics, and culturally responsive approaches. Chinese contextual studies emphasize practical applications, increasingly intersecting with interdisciplinary education.

Mathematics Learning. Evidence confirms mathematical history/culture positively influences affective domains, enhancing cognitive engagement through non-intellectual factors.

6.2 Recommendations

Prioritize Implementation Evaluation. While integration frameworks exist internationally, empirical studies evaluating efficacy across diverse approaches and student demographics remain urgent. Future work should establish evidence-based assessment protocols.

Strengthen Competency-Oriented Practice. Mathematical history/culture uniquely cultivates core competencies (abstraction, modeling, reasoning). Yet, few studies align with new curriculum standards. Research must bridge theory and practice in competency development.

Explore Interdisciplinary Synergies. Leverage STEAM education momentum to: Design cross-disciplinary teaching cases from historical/cultural perspectives. Investigate impacts on integrative thinking. Position mathematics as connective tissue across knowledge domains.

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