

Research Trends in Mathematics Textbooks at the Compulsory Education Stage: A CiteSpace-Based Review of Web of Science Literature

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Abstract: Research on mathematics textbooks is a central area of mathematics education at the compulsory education stage. Based on 112 articles on mathematics textbooks in primary and lower secondary education published in the Web of Science Core Collection from 2005 to 2024, this study uses CiteSpace 6.2.R6 and combines quantitative analysis with qualitative interpretation to examine international research trends in terms of annual publication output, major research contributors, and keyword patterns. The results show that international research on mathematics textbooks has developed around four major themes: textbook content analysis, comparative textbook research, textbook-use research, and digital mathematics textbook research. The field has gradually expanded from the analysis and comparison of textbook content to broader concerns with textbook use, learning effects, and technology-supported curriculum resources. Based on these findings, this study offers implications for future research on mathematics textbooks in China at the compulsory education stage.

Keywords: Mathematics Textbooks; Compulsory Education; Knowledge Mapping

1. Introduction

Mathematics textbooks are essential resources for achieving curriculum goals and supporting classroom instruction. International comparative studies in mathematics education, such as IAEP, TIMSS, and PISA, have shown that mathematics curricula and textbooks have a significant influence on students' learning^[1]. Since China's new curriculum reform, textbook research has received increasing scholarly attention. Over the past two to three decades, research on mathematics textbooks has also gained growing attention in international mathematics education. The first International Conference on Mathematics Textbook Research and Development was a landmark event in the development of mathematics textbook research^[2]. Therefore, mathematics textbooks are not merely carriers of prescribed content; they mediate the relationship between intended curriculum, classroom implementation, and students' mathematical learning. Understanding how mathematics textbooks are studied internationally is thus important for improving textbook design, textbook use, and mathematics education more broadly.

Mathematics textbook research has developed along several interconnected lines. From a static perspective, studies have analyzed textbooks as written texts, focusing on the organization of mathematical topics, the design of problems, cognitive demand, reasoning, values, culture, and alignment with curriculum standards^[3-5]. From a dynamic perspective, studies have examined how textbooks are developed, selected, used, and evaluated in educational practice. This line of inquiry has expanded attention from textbook content to teachers' and students' use of textbooks, the relationship between textbook characteristics and student achievement, and the emergence of digital mathematics textbooks^[6-7]. Existing reviews have summarized important developments in this field and have provided useful methodological references, including literature classification and CiteSpace-based knowledge mapping^[8-9]. However, these reviews have mainly focused on domestic studies or on primary and secondary mathematics textbooks in general. Systematic science-mapping analyses of international mathematics textbook research specifically at the primary and lower secondary education levels remain limited. As a result, the overall development trajectory, collaboration structure, keyword patterns, and major research themes of this field still require further clarification from an international perspective.

To address this gap, the present study reviews articles on mathematics textbook research at the compulsory education stage, corresponding mainly to primary and lower secondary education, retrieved

from the Web of Science Core Collection from 2005 to 2024. Using CiteSpace, this study conducts a visual and bibliometric analysis of annual publication output, major contributing countries and regions, research institutions, authors, and keyword patterns. It further combines quantitative mapping with qualitative interpretation of representative studies to identify the major research themes in the field. Specifically, this study seeks to answer the following questions: (1) What are the publication trends and major research contributors in international mathematics textbook research at the primary and lower secondary education levels? (2) What keyword patterns and research clusters characterize this field? (3) What major research themes can be identified from the bibliometric results and representative studies? By answering these questions, this study aims to provide a concise overview of international mathematics textbook research and to offer implications for future research on mathematics textbooks in China and beyond.

2. Data and Methods

2.1 Data Sources

To ensure that the selected literature was current and representative, records were retrieved from the SCI-EXPANDED and SSCI indexes in the WOS Core Collection. The Topic field was searched using “math textbook*” OR “mathematics textbook*” as the search terms. The document type was limited to articles, and the publication period was set from 2005 to 2024. The initial search yielded 217 records. After review papers and records outside the scope of compulsory education were excluded, such as studies on mathematics textbooks used in higher education or upper secondary education, 112 articles remained for the bibliometric analysis.

2.2 Analytical Methods

CiteSpace 6.2.R6 was used to conduct a visual analysis of the selected literature. The analysis covered annual publication output, major contributing countries and regions, research institutions, and contributing authors. This provided a broad overview of the development of mathematics textbook research at the compulsory education stage. Keyword co-occurrence and cluster analyses were also conducted. Based on high-frequency keywords, clustering results, and close reading of key publications, the main topics in international mathematics textbook research were further identified.

3. Results

This section reports the bibliometric results of 112 articles on mathematics textbooks in primary and lower secondary education retrieved from the Web of Science Core Collection. To avoid overlap with the subsequent thematic review, the analysis here is limited to descriptive patterns in publication output, research contributors, and keyword structures. These results provide empirical evidence for identifying the major research themes discussed in the next section.

3.1 Bibliometric Overview

As shown in Figure 1, annual publication output showed a fluctuating but generally upward trend from 2005 to 2024. The development of the field can be divided into three stages. The first stage (2005-2011) was an exploratory period, in which studies mainly examined explicit textbook content such as fractions, problems, and task design, with only limited attention to textbook use. The second stage (2012-2017) was characterized by fluctuating growth. During this period, comparative studies, textbook evaluation, and studies of textbook use became increasingly visible. The third stage (2018-2024) was a period of sustained activity. Research attention gradually moved beyond textbook content itself to the influence of textbooks on students' mathematics learning. Attention to digital mathematics textbooks also increased.

The country and region network included 36 countries and regions. In terms of both publication output and betweenness centrality, the United States and the Chinese mainland were the most influential contributors. The United States contributed 32 articles, mainly focusing on textbook content, textbook use, textbook evaluation, and the relationship between textbooks and students' mathematics achievement. The Chinese mainland contributed 18 articles, with studies mainly addressing textbook content and textbook use. Its content-oriented studies expanded from conventional topics such as knowledge themes

and problems to learning interest, mathematical modeling, and mathematical games. Some studies on textbook use also adopted large-scale survey designs, which helped overcome the small-sample limitation found in earlier research.

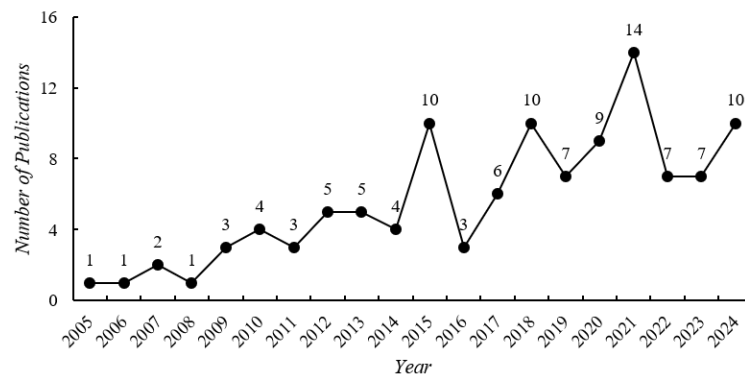


Figure 1: Publication Trends in Mathematics Textbook Research.

The author and institution networks involved 246 authors and 157 institutions. Productive scholars were mainly affiliated with universities and research institutions in China's Taiwan region, the Chinese mainland, the United States, Spain, Israel, and Germany. Der-Ching Yang from National Chiayi University in China's Taiwan region had the highest publication output, with a strong focus on international comparative studies of mathematics textbooks. Beijing Normal University ranked first among institutions, and its related studies mainly focused on textbook content analysis. Overall, the collaboration networks showed a multi-centered and locally dense structure, indicating that collaboration in this field has developed within several small research communities rather than through a highly integrated global network.

3.2 Keyword Trends and Cluster Analysis

Keywords provide a concise summary of the core content of an article. A higher keyword frequency usually indicates greater scholarly attention to a topic. In this study, CiteSpace was used to merge similar keywords, rank them by frequency, and select those with betweenness centrality values above 0.1. As shown by the top ten high-frequency keywords in Table 1, international research on mathematics textbooks has mainly focused on comparative studies and content analysis. In terms of research content, attention has been given to cognitive demand, task design, and problem solving in mathematics textbooks. In terms of educational level, primary education has been the major focus.

Table 1: Top 10 Keywords by Frequency.

Rank	Keyword	Frequency	Betweenness Centrality	Rank	Keyword	Frequency	Betweenness Centrality
1	mathematics textbooks	100	0.78	6	content analysis	14	0.24
2	mathematics education	44	0.67	7	cognitive demand	8	0.18
3	primary education	40	0.89	8	problem solving	6	0.58
4	textbook analysis	34	0.51	9	mathematics task	6	0.18
5	comparative analysis	14	0.67	10	curriculum reform	6	0.16

In the keyword cluster analysis conducted with CiteSpace, closely related keywords were identified and grouped into corresponding clusters (see Figure 2). The modularity Q value and silhouette S value are commonly used to evaluate clustering quality. A Q value greater than 0.3 indicates a significant cluster structure, and an S value greater than 0.7 indicates a reliable clustering result. In this study, the Q value was 0.7956 and the S value was 0.9612, indicating that the clustering result was reliable. Based on the high-frequency keywords and keyword clusters, content analysis, comparative studies, digital textbooks, textbook use, and the effects of textbook use were identified as core topics in international research on mathematics textbooks.

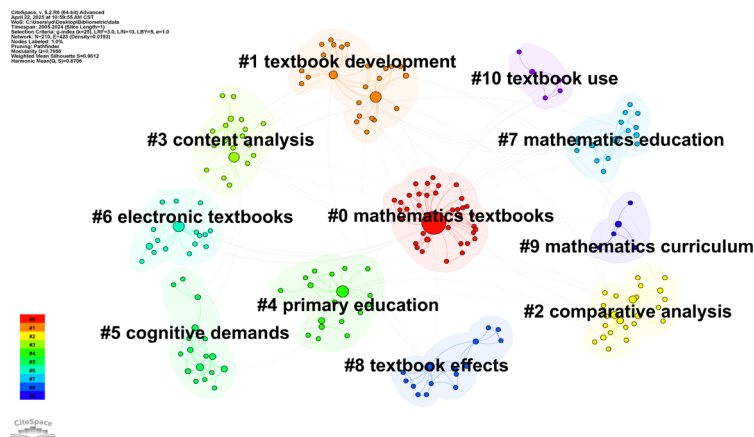


Figure 2: Keyword Clustering Map.

Taken together, the bibliometric and keyword results indicate four major research themes. First, textbook content analysis remains the most stable and foundational theme, with its scope gradually expanding from visible textbook content to deeper issues such as reasoning, values, culture, and discourse. Second, comparative textbook research continues to be an important approach, moving from descriptive comparison of textbook content toward broader comparisons involving textbook use and effects. Third, textbook-use research has gradually shifted from a teacher-centered perspective to a more balanced concern with teachers, students, and their interactions with textbooks. Fourth, digital mathematics textbooks have become an emerging theme, especially in relation to feedback mechanisms, student engagement, classroom interaction, and learning outcomes. These four themes are examined in greater depth in the following section.

4. Major Research Themes

Based on the keyword clusters and a close reading of representative studies, four major themes can be identified in international research on mathematics textbooks at the primary and lower secondary education levels: textbook content analysis, comparative textbook research, textbook use and effects, and digital mathematics textbooks. These themes are closely connected: content analysis clarifies what textbooks present, comparative research situates textbook features across educational systems, use-oriented studies examine how textbooks are enacted by teachers and students, and digital textbook research extends the field to technology-mediated curriculum resources.

4.1 Textbook Content Analysis

Textbook content analysis is one of the most fundamental and long-standing themes in mathematics textbook research. International studies on mathematics textbook content have developed a multi-level analytical framework, examining textbooks in terms of their overall structure, mathematical topics, and specific textual elements. Research on overall structure has addressed textbook organization, genre, and modes of presentation. For example, Namukasa examined Ugandan mathematics textbooks and found that, although some reflected reform-oriented pedagogy, many still needed further revision to align with renewed curricula, pedagogical goals, and locally appropriate learning resources^[10]. Research on mathematical topics has focused on how textbooks treat areas such as numerical operations, fractions, functions, and equations. For instance, Ding et al. examined how a widely used standards-based Chinese primary mathematics textbook series supported functional thinking, a key component of algebraic thinking, through the design and sequencing of function-related tasks^[11]. Other studies have examined specific textual elements, such as problems, diagrams, and language. Vicente et al. compared word-problem-solving approaches in Spanish and Singaporean primary mathematics textbooks and found that the Singaporean textbooks placed greater emphasis on reasoning, thereby providing stronger scaffolding for learning to solve word problems^[12]. Gea et al. analyzed activities involving statistical tables in primary mathematics textbooks and found that most activities focused on reading information from frequency tables, with personal contexts appearing most often^[13].

Recent research on mathematics textbook content has increasingly focused on the culture and values embedded in textbooks and on the role of sociocultural factors in textbook development. Using Sam and

Ernest's classification of values in mathematics education, Daher analyzed the Geometry and Measurement unit of a Palestinian sixth-grade mathematics textbook and found that epistemological values appeared most often, followed by personal and social values^[14]. From a multicultural perspective, Ju et al. examined how Korean mathematics textbooks incorporated the history of mathematics. The analysis showed that the presentation of historical content was still largely shaped by a Eurocentric narrative, limiting its potential to promote students' understanding of diversity^[15]. From a cultural perspective, Fan et al. compared the Chinese series One Lesson, One Exercise with its English adaptation, The Shanghai Maths Project Practice Book for the English National Curriculum, and showed that cultural factors played an important role in textbook adaptation and development^[16].

4.2 Textbook Comparison

Comparative textbook research has developed alongside increasing international exchange in mathematics education. This theme examines similarities and differences among textbook systems, either across countries and regions or across textbook series within the same country. Such studies have compared textbook structures, mathematical topics, problem types, visual representations, and pedagogical orientations. For instance, comparisons of arithmetic word problems in Singaporean and Spanish primary textbooks showed differences in the quantity, structure, and visual support of problems, while research on mathematical games in Chinese secondary textbooks revealed uneven distribution across series and grade levels^[17-18].

The scope of comparative research has also moved beyond textbook content. Recent studies have compared textbook evaluation, textbook use, and digital resources, thereby linking textual features with broader educational contexts. In studies of textbook effects, Bellens et al. examined how the use of different Grade 4 mathematics textbooks in Flanders was associated with students' mathematics achievement and equity across content and cognitive domains^[19]. In studies of textbook use, Wang et al. compared secondary students' textbook use in Shanghai and England, showing differences in frequency, learning situations, and self-regulation^[20]. Usiskin further noted that paper textbooks and digital platforms differ in how they present symbolization, deduction, modeling, algorithms, and representations^[21]. These studies suggest that comparative textbook research is shifting from the description of cross-system differences toward explanations of how textbook design, curriculum culture, and classroom practice interact.

4.3 Textbook Use in Teaching and Learning

Research on textbook use regards textbooks not only as written texts, but also as curriculum resources enacted by teachers and students. Studies of teachers' textbook use have mainly addressed how teachers interpret and adapt textbooks, what challenges they encounter, and how textbook use influences teaching practice. Massey and Riley used case studies to explore how mathematics teachers think when reading mathematics textbooks. Their study suggests that textbook use involves active interpretation of textbook content rather than simply following written materials^[22]. At the same time, studies have identified gaps between curriculum intentions and classroom implementation^[23], as well as teachers' generally positive perceptions of textbooks as resources for teaching and instructional change^[24].

Research on students' textbook use has focused on patterns of use, relationships with mathematics achievement, and the factors that influence such use. Students use textbooks for practice, homework, review, and independent learning, yet these practices are strongly mediated by teachers' guidance, textbook design, and students' learning needs^[25-26]. Most studies suggest that differences in textbook content organization, task types, and cognitive demands may affect students' mathematical development and achievement^[27-28]. However, Blazar et al. found only a weak relationship between textbook selection and student achievement^[29]. This discrepancy may be related to differences in research design. Overall, this theme marks a shift from viewing textbooks as prescribed curriculum materials to examining them as resources-in-use within teaching and learning processes.

4.4 Digital Mathematics Textbooks

The development of educational technologies has made digital mathematics textbooks an emerging theme in the field. Compared with traditional paper textbooks, digital textbooks can provide interactive diagrams, automated feedback, formative assessment, and records of students' learning processes. These features create new possibilities for personalized learning. Existing studies have mainly examined specific digital functions and their effects on learning. Automated feedback has received particular

attention, but Rezat found that correct responses in digital environments do not necessarily indicate conceptual understanding and that feedback does not always support conceptual development as intended^[30]. Other studies have investigated the effects of digital mathematics textbooks at student and classroom levels. Intervention studies suggest that digital textbooks may improve mathematics achievement and learning interest^[31-32]. Wijaya's classroom video analysis further showed that digital textbooks can support more student-centered interaction, especially student–student and student–technology interaction, while improving the diversity and quality of classroom interaction^[33]. Overall, digital textbook research has moved mathematics textbook studies toward issues of interaction, feedback, data, and technology-supported learning. Future research should further examine teachers' adaptation to digital textbooks, the integration of digital resources into classroom practice, and the conditions under which digital features genuinely support mathematical understanding.

5. Discussion and Implications

The findings of this study show that international research on mathematics textbooks at the primary and lower secondary education levels has expanded from textbook analysis and comparison to broader concerns, including textbook use, the effects of textbooks on teaching and learning, and digital resources. These developments provide useful implications for future mathematics textbook research in China. Relative to the broader international literature, research in China has produced a substantial body of work on textbook analysis and comparison, whereas textbook use and the effects of textbooks on teaching practice have received comparatively less attention. Future research should therefore build on existing strengths while giving more attention to how textbooks function in teaching and learning practice.

First, future research should move beyond textbook analysis and strengthen research on the development, use, and effects of mathematics textbooks. In China, the analysis of mathematics textbooks is relatively well developed and remains valuable for understanding how mathematical knowledge, problems and values are organized in written materials. However, textbook analysis alone cannot explain how textbooks influence teaching and learning. Future studies should therefore examine the full process through which textbooks are developed, interpreted, used, and evaluated. In particular, more attention should be paid to the effects of mathematics textbooks on teaching and learning. Such work would help the field develop a stronger focus on causal questions.

Second, comparative textbook research should move from descriptive comparison to explanatory comparison. Existing studies have identified many differences among textbooks from different countries, regions, or editions, such as differences in topic arrangement, problem types, examples, representations, and curriculum structure. These comparisons are useful, but they need to go further by explaining why such differences exist and how they matter educationally. Future studies should relate textbook differences to curriculum standards, cultural traditions, assessment systems and students' learning opportunities.

Third, future research on textbook use should pay more attention to students' use of mathematics textbooks. In Chinese research, textbook use has often been examined from the teacher's perspective, focusing mainly on current practices, influencing factors, and effects on teaching practice. This perspective remains important, but it is not sufficient for understanding how textbooks support student learning. More empirical studies are therefore needed to examine how students read and use mathematics textbooks, how this use varies across learning contexts, and how it is associated with mathematical achievement.

Fourth, research on digital mathematics textbooks in China should be strengthened. Compared with related international research, research in China is still at an early stage. At the same time, the development of digital textbooks and smart learning platforms is advancing rapidly in China, making further empirical research increasingly necessary. Future studies should examine not only whether digital mathematics textbooks are effective, but also under what conditions they are effective. Particular attention should be paid to how teachers integrate digital textbooks into classroom instruction, how students interact with them, and how digital features support students' mathematical understanding.

6. Conclusion

This study used CiteSpace to analyze international research on mathematics textbooks at the primary and lower secondary education levels from 2005 to 2024. The results show a fluctuating but generally upward trend in this field, indicating growing scholarly attention to mathematics textbooks as important

curriculum resources. Four major research themes were identified: textbook analysis, comparative textbook research, textbook use, and digital mathematics textbooks. These themes suggest that the field has gradually expanded from textbook analysis and comparison to broader concerns, including textbook use, the effects of textbooks on teaching and learning, and digital mathematics textbooks. For future research in China, more attention should be paid to textbook use and to the effects of textbooks. Research on digital mathematics textbooks should also be strengthened through more systematic empirical studies.

Acknowledgements

This study was supported by the Postgraduate Education Reform Project of Henan Province “Mechanism Construction and Application Research of GenAI-Enabled Digital Teaching Design Ability Cultivation for Master of Education” (Grant No. 2025SJGLX252Y).

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