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Bibliometric Analysis of Comparative Studies in Mathematics Textbook Analysis Research: Trends, Gaps, and Future Directions (Mark Revision Manuscript)

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ABSTRACT

While the cross national comparative analysis of mathematics textbooks is an expanding field of research, a dedicated bibliometric mapping to identify research gaps and provide clear directions for future inquiry is notably absent. Therefore, this study aims to provide a bibliometric analysis that maps publication trends, identifies the most influential authors and documents, and delineates research gaps to offer clear signposts for future research. The methodology involves a qualitative analysis and mapping of data retrieved from the Scopus database for the period 2010–2024. Following a screening process based on inclusion and exclusion criteria, a final corpus of 89 papers was selected for synthesis in this study. The analysis software, VOSviewer, was employed for keyword co-occurrence and co-citation mapping, supplemented by distribution diagrams for trend analysis. Four main findings emerged: first, there has been a significant and increasingly multidisciplinary growth in publications. Second, a thematic evolution is observed, shifting from structural reviews towards more complex evaluative approaches focused on cognitive load and learning implications. Third, research gaps were identified concerning the linguistic presentation of mathematical concepts and the inclusion of social values. Finally, the analysis highlights the most influential authors and articles in the field. Implications of this study are expected to serve as a compass for researchers, guiding them toward achieving novelty in future comparative analyses of mathematics textbooks.

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A. INTRODUCTION

Mathematics textbooks are a cornerstone of educational systems and curricula, functioning as a benchmark for the execution of learning activities within schools (Abdullah & Shin, 2019). One key aspect of this scholarly focus is the organizational structure of textbook material, as it provides insights into the underlying approaches for instructional content construction. Cross national comparative analysis of mathematics textbooks plays a pivotal role in enhancing the quality of learning. The objective of cross-national research on mathematics textbooks is to delineate their respective merits and drawbacks, so that the resulting insights can guide the development of future texts (Lin & Yang, 2015). An evaluation of how particular topics are delivered in textbooks can pinpoint areas requiring enhancement to support effective learning outcomes (Erbas et al., 2012). Within the framework of international comparisons, textbook analysis plays a key role in broadening the comprehension of worldwide mathematics teaching practices (Hendriyanto et al., 2023). It is contended by researchers that an analysis of textbooks

from multiple countries can reveal foundational similarities and differences regarding the learning opportunities in mathematics available to students (Kul et al., 2018).

Diversity of focus in comparative analyses of mathematics textbooks illustrates the extensive scope of inquiry within cross national mathematics education. These studies reflect the expanding field of mathematics education research. Several studies have concentrated on specific content areas, such as solid geometry (Zhang, 2021), statistical processes and data representation (Gea et al., 2022; Jones et al., 2017), and the concept of division (Pang & Kim, 2017). Furthermore, geometric content has been a primary focus of investigation, encompassing analyses of geometry problems (Wang et al., 2017), geometric transformations (Takeuchi & Shinno, 2019), and the topic of quadrilaterals (Abdullah & Shin, 2019). Other studies have explored pedagogical elements such as problem-solving activities (van Zanten & van den Heuvel-Panhuizen, 2018; Vicente et al., 2022), mathematical modelling tasks (Wei et al., 2024) and programming-based approaches (Nyman et al., 2024). Research has also addressed aspects like the values embedded in textbooks (Horzum & Yildiz, 2023), the introduction of set theory (Hendriyanto et al., 2023), trigonometry (Sianturi & Yang, 2017), and the concept of gradient (Choy et al., 2020). Additionally, issues such as sustainability-related activities (Pang & Kim, 2022), arithmetic word problems (AWP), and problem posing have garnered attention (Deringöl & Guseinova, 2022). Over the past few decades, international comparative studies in mathematics education have significantly contributed to the understanding of the diverse directions and approaches in instructional practices across various nations.

As the field of comparative mathematics textbook studies has expanded, a number of researchers have begun conducting systematic literature reviews to chart its developmental trajectory and research directions. In their Systematic Literature Review (SLR) covering 2002 to 2022, Ismail & Rosli (2022) revealed that most studies centered on elementary school mathematics textbooks, with a primary focus on numbers and operations, geometry, and algebra. Concurrently, a meta-analysis by Gökçek & Çelik (2020) demonstrated that the bulk of textbook analysis research concentrates on the activities and problems presented therein. Similarly, Chang & Silalahi (2017) affirmed the scarcity of research that holistically investigates mathematics textbooks, noting that the main focus has been on content distribution, particularly for numbers and operations in basic education.

While Systematic Literature Review (SLR) provide valuable narrative summaries, they cannot quantitatively map the intellectual structure and evolutionary trajectory of a research field. This is precisely where bibliometric analysis offers a distinct advantage, as its ability to visualize the connections among authors, keywords, and documents allows for a clear identification of research trends and gaps (Donthu et al., 2021). Previous bibliometric analysis has been conducted in related areas. For instance, Wachyudi et al. (2022) performed a study in the domain of EFL textbooks. Additionally, Sugiarni et al. (2024) conducted a bibliometric analysis of mathematics textbook research, focusing on publication trends in relation to emerging research topics. However, to date, no bibliometric study has been specifically conducted to map the trends, gaps, and recommendations within the subfield of comparative mathematics textbook analysis, as distinct from the broader field of general mathematics textbook research. Therefore, the novelty of this study lies in its use of a bibliometric analysis

technique grounded in science mapping. This approach is augmented with supplementary analyses of temporal dimensions, country of publication origin, and publication sources. By leveraging science mapping within this bibliometric framework, the research identifies publication patterns, research trends, emerging themes (Chen et al., 2023), author relationships (Pessin et al., 2022), and research gaps and opportunities (Chen et al., 2023).

Therefore, in response to the identified research gap and the urgency of the topic, this study aims to fulfill several objectives. It seeks to delineate publication trends by analyzing distributions across years, journals, and country affiliations, while also mapping the thematic evolution of the research. Building on this analysis, the study will then identify critical research gaps and pinpoint the principal researchers and foundational publications that have shaped the field. Ultimately, these findings will be synthesized to formulate strategic recommendations that guide subsequent research toward more innovative and contemporary inquiries.

B. METHODS

This study employs a qualitative approach utilizing bibliometric analysis, mapping trends and identifying the relationships among authors, topics, and scholarly publications (Öztürk et al., 2024). The bibliometric analysis procedure follows four stages: (1) defining the research objectives, (2) data collection and screening, (3) data analysis and visualization, and (4) interpretation of the results (Öztürk et al., 2024). This study focuses on the science mapping technique, analyzing conceptual networks to represent the relationships among keywords and topics, as well as citation networks to reveal research trajectories.

1. Research Objectives

This study aims to identify publication trends based on annual distribution, journal sources, and country affiliations; describe the evolution of explored research topics; identify research gaps based on the topic mapping; identify key researchers and the most cited publications that serve as primary references; and provide strategic recommendations for future directions in the comparative analysis of mathematics textbooks. To achieve these objectives, this study focuses on the science mapping technique. This involves an analysis of conceptual networks to represent the relationships among concepts, keywords, or topics within the research field, as well as citation networks to uncover the historical development and interconnectedness of documents in this area (Öztürk et al., 2024).

2. Data Collection and Filtering

Data for this study were retrieved from the Scopus database. This platform was selected due to its capacity for providing extensive bibliometric datasets efficiently and its support for various analysis tools (Moral-Muñoz et al., 2020). Scopus is widely acknowledged as one of the most comprehensive citation databases accessible today (Zhu & Liu, 2020). The search for relevant documents utilized a specific Boolean query string formulated as ("textbook analysis" OR "textbook comparison" OR "comparative analysis") AND ("mathematics textbook"). The rationale for this query was to precisely define the search parameters in accordance with the study's aim, which was to identify literature explicitly addressing the analysis or comparison of mathematics textbooks. In order to maintain data validity and relevance, a filtering process was implemented using predefined eligibility criteria, which is a critical measure for ensuring

analytical quality (Zupic & Čater, 2014). The inclusion and exclusion criteria are presented in Table 1. Publications not meeting these stipulations were excluded. This screening process culminated in a final corpus of 89 relevant articles. Subsequently, the dataset corresponding to these articles was exported in two formats: CSV, for conducting descriptive quantitative analysis (of annual, topical, and country-level trends), and RIS, for visualization and mapping with VOSviewer, as shown in Table 1.

Table 1. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Document Type	Documents must originate from journals or conference proceedings	Documents other than journal articles or conference proceedings (e.g., books, book chapters, reviews, letters).
Language	Documents must be published in English	Documents not published in English
Publication Timeframe	Documents must be issued within the 2010–2024 timeframe	Documents issued outside the 2010–2024 timeframe
Theme	Comparative analysis of mathematics textbooks	Besides comparative analysis of mathematics textbooks

3. Data Analysis and Visualization

Analysis and visualization phase utilized the Science Mapping technique to investigate the networks connecting authors, documents, concepts, and citations (Öztürk et al., 2024), alongside a quantitative analysis to delineate the research distribution across publication years, journals, and country affiliations. VOSviewer was utilized as the bibliometric analysis software in this study, selected for its high effectiveness in data visualization, especially in constructing easily interpretable network maps (Donthu et al., 2021) and for its renowned intuitive and user-friendly interface (Moral-Muñoz et al., 2020). The findings from the distribution analysis were rendered as visual diagrams. Additionally, co-occurrence analysis was performed, employing overlay visualization to trace the periodic development of research themes and density visualization to pinpoint research topics that have received less exploration. Further analysis involved author co-citation to identify key researchers based on total citations, while document co-citation was applied to ascertain the primary reference publications with the highest citation impact (Öztürk et al., 2024).

4. Data Interpretation

In the interpretation stage of the research findings, the discussion is divided into four main aspects: a review of publication trends in the comparative analysis of mathematics textbooks; an examination of dominant research topics; the identification of research gaps emerging from the topic mapping; and the identification of key researchers and publications that have made significant contributions to the field. Based on this interpretation, strategic recommendations for the future development of comparative research on mathematics textbooks are also presented, with the aim of enriching the literature in this area.

C. RESULT AND DISCUSSION

1. Publication Trends of Comparative Research Analysis of Mathematics Textbooks

An expanding field of research necessitates periodic review. In this section, the publication trends in the comparative analysis of mathematics textbooks are examined based on the distribution of publication year, author country affiliation, and source journal. This analysis aims to provide an up-to-date overview of the developmental trajectory of research in this field up to the present day, as shown in Figure 1.

Figure 1. Distribution of Research Publication Years 2010 - 2024

As depicted in Figure 1, the distribution of research publications from 2010 to 2024 reveals an increasing trend in the number of studies on the comparative analysis of mathematics textbooks. In the early part of the decade, the number of publications was relatively low and stable. However, a significant surge occurred starting in 2018, likely influenced by a growing interest in comparing educational policies related to curriculum evaluation and a heightened focus on student learning outcomes through studies like PISA and TIMSS (Abdiqayumovich, 2021). This pattern suggests that comparative textbook analysis has emerged as an established research avenue within mathematics education, particularly concerning curriculum and instructional practices across various nations, as shown in Figure 2.

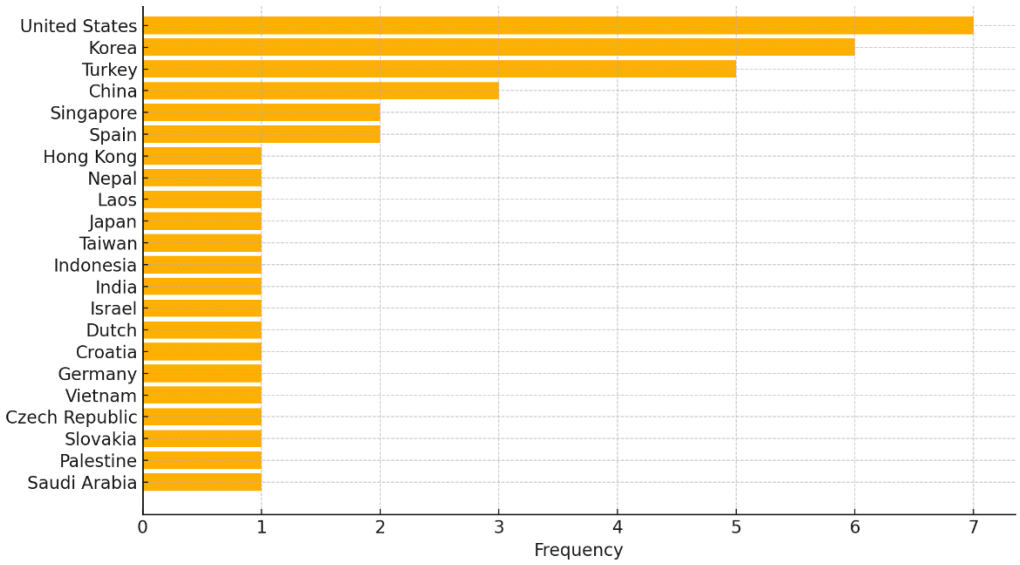

Figure 2. Distribution of Country Publication

As illustrated in Figure 2, the geographical distribution of research in comparative mathematics textbook analysis is dominated by the United States, Korea, and Turkey. This dominance reflects the advanced state of educational research and policy reforms in these developed nations (Elsenberger & Kendzia, 2023). In contrast, participation from developing countries, as well as several nations in Eastern Europe and Southeast Asia, remains markedly limited. This data indicates a representational imbalance in comparative mathematics textbook studies, highlighting the importance of broadening the scope of cross-national research and fostering international collaboration. Such efforts are crucial for creating a more inclusive understanding of textbook use across diverse cultural contexts and educational systems (Scheel & De Luca, 2020), as shown in Figure 3.

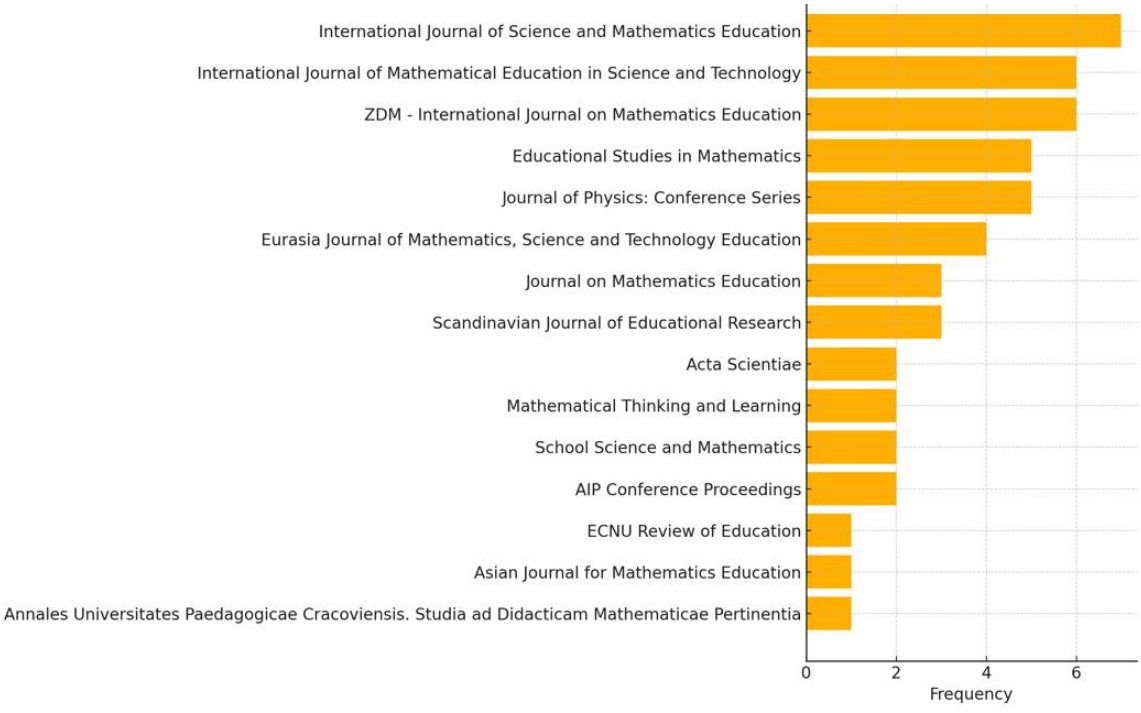

Figure 3. Journal Publication Distribution

The bibliometric mapping of journals that most frequently publish articles on the comparative analysis of mathematics textbooks, as depicted in Figure 3, shows that the highest contributions come from reputable journals in mathematics and science education. This is exemplified by leading journals such as the *International Journal of Science and Mathematics Education* and the *International Journal of Mathematical Education in Science and Technology*. This finding indicates that comparative mathematics textbook research is no longer a peripheral topic within the discipline. This is because comparative textbook research is closely tied to shifts in curriculum and educational policy, which directly influence the design and adoption of textbooks worldwide (Hwang & Pang, 2023).

2. Evolution of Research Topics

The overlay visualization mapping of keyword co-occurrence in Figure 4 provides a temporal map of the development of comparative mathematics textbook research between 2010 and 2024. The initial phase, represented by colors from purple to dark blue, reveals that research between 2010 and 2018 was primarily concerned with the structural and presentational features of textbooks. Studies from this era generally emphasized content description, sequencing of material, task presentation, and the coherence between textbooks and the prevailing curriculum (Fan et al., 2013; Pepin et al., 2013).

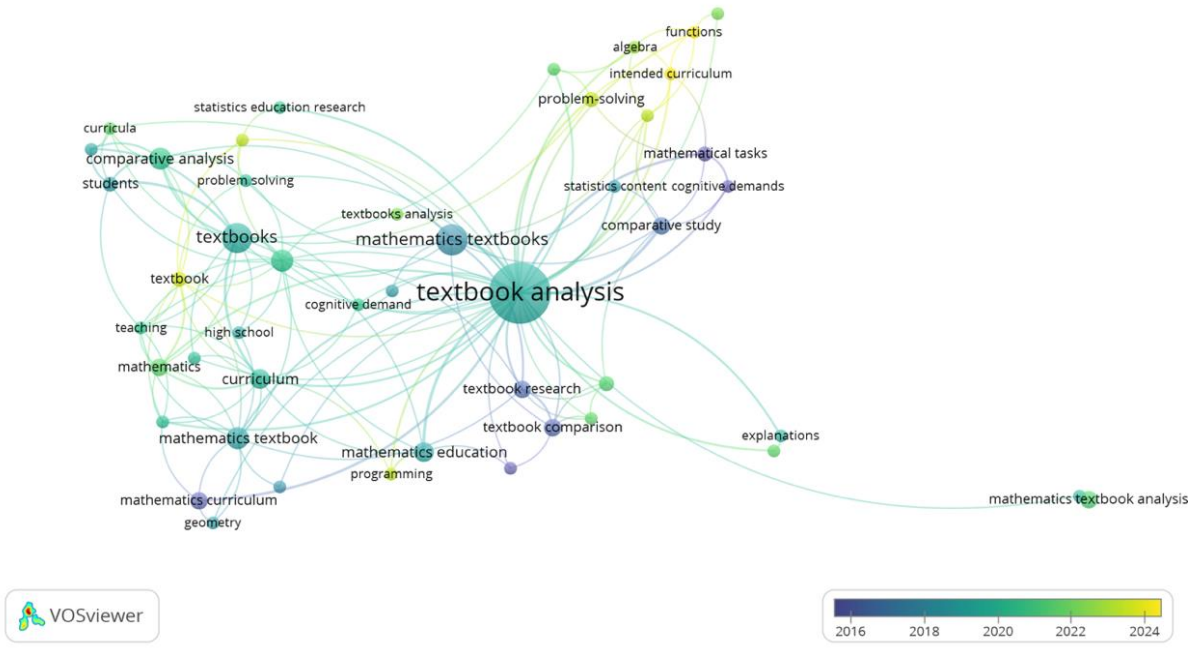

Figure 4. Overlay Visualization Co-occurrence Analysis

A clear progression is visible in the later period, marked by a color shift towards green and yellow. This phase is defined by the rise of topics including 'intended curriculum,' 'cognitive demand,' 'statistics education research,' and the integration of programming. Thematic shift in comparative textbook research is evolving towards content analysis with an emphasis on contemporary applications, such as the integration of statistical (Gea et al., 2022) and programming skills (Nyman et al., 2024). Moreover, a new potential research avenue is

emerging: the analysis of the stylistic presentation of mathematical concepts, especially for evaluating learning quality and the accessibility of the language used. Analysis of linguistic presentation is emerging as a novel research area within the study of mathematics textbooks, driven by the understanding that the language used in mathematics instruction positively influences students' attitudes, motivation, and conceptual understanding (O'Keeffe & O'Donoghue, 2015; Safitri et al., 2024). In summary, the field's progression marks a shift from a structural focus to evaluative analysis that underscores the interconnection of content, cognitive requirements, and their impact on learning.

3. Identification of Research Gaps

Figure 5 below presents the density visualization from the keyword co-occurrence analysis in the comparative study of mathematics textbooks, generated using VOSviewer. In this map, the colors denote the density of keyword co-occurrence and interconnectedness: yellow indicates high-density areas of frequently researched topics; green signifies medium density; and blue to purple represent low-density areas corresponding to less explored topics in the literature (Rachmawati et al., 2023). The visualization highlights several isolated regions colored blue or light green, indicating low levels of exploration and thus potential research gaps. As shown in Figure 5, the keywords 'explanations' and 'programming' appear in these low-density areas. This finding is significant because these aspects are highly relevant to the transformation of 21st-century learning, particularly concerning the integration of digital literacy and students' computational thinking (Funk et al., 2021; Nyman et al., 2024).

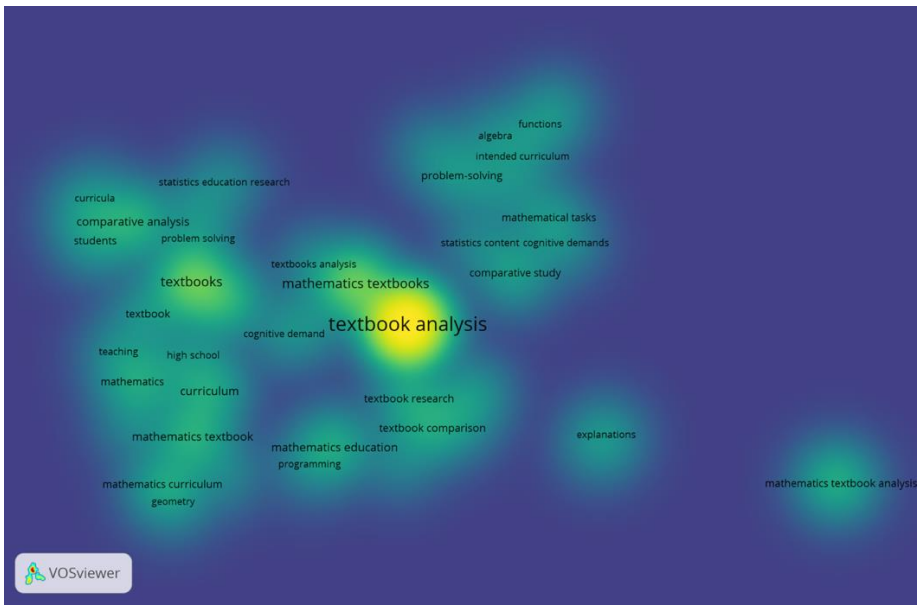

Figure 5. Density Visualization Co-occurrence Analysis

Figure 6 reveals a diverse thematic landscape within the comparative study of mathematics textbooks. Among specific subjects, geometry and statistics emerge as the most prominent areas of study. Concurrently, regarding overarching themes, the field is largely preoccupied with curriculum comparisons and analyses of problem-solving integration within textbooks. This focus implies that comparative textbook research is still heavily oriented towards universal core content that serves as a benchmark in international evaluations. Nevertheless,

notable for their relative absence are topics concerning the examination of language and the infusion of social values in mathematics textbooks. The former represents a critical oversight, as analyzing linguistic presentation investigates how mathematical language shapes students' conceptual understanding (Berger, 2019; O'Keeffe & O'Donoghue, 2015). The latter, the analysis of social and ethical values, assesses how principles like cooperation, empathy, and justice are incorporated into the learning activities presented in textbooks (Daher, 2021; Piatek-Jimenez et al., 2014).

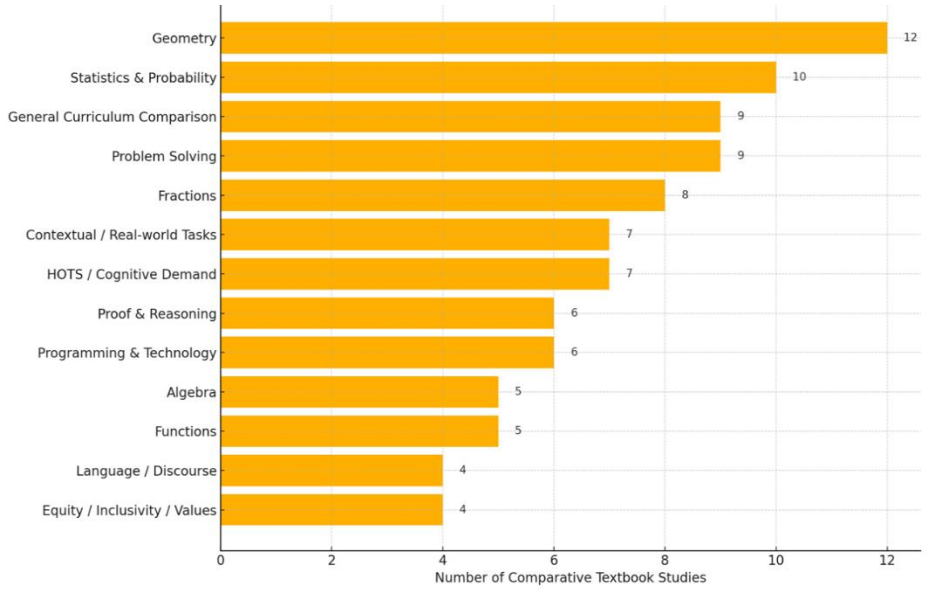

Figure 6. Trends in Comparative Mathematics Teztbook Research Topics

4. Key Authors and Publications

Table 2. Top 10 Authors with the Most Citations

Author	Citations
Fan, Lianghuo	252
Miao, Zhenzhen	176
Zhu, Yan	176
Van Den Heuvel-Panhuizen, Marja	168
Wijaya, Ariyadi	129
Doorman, Michiel	129
Charalambous, Charalambos Y.	129
Delaney, Seán	129
Hsu, Hui-Yu	129
Mesa, Vilma	129

As shown in Table 2, the author citation data identifies the 10 most influential researchers in the field of comparative mathematics textbook analysis between 2010 and 2024. The contributions of the top three authors, for example, span a range of critical topics. These include comprehensive overviews of the research landscape (Fan et al., 2013) and the establishment of methodological standards for textbook analysis (Fan, 2013b). High citation numbers are considered a surrogate for the acknowledgment of ideas, a process that forms the core of expert validation in the scholarly community (Caon & Trap, 2020). The prevalence of citations to these

authors signifies that their publications are foundational references and that they are esteemed as leading experts for consultation in the ongoing research and development of mathematics textbooks. Consequently, this analysis not only pinpoints figures of high authority in mathematics textbook studies but also offers a credible benchmark for the creation of more complex and advanced textbooks.

Table 3. Top 10 Articles with the Most Citations

Cites	Title	Authors	Year
176	Textbook research in mathematics education: Development status and directions (Fan et al., 2013)	Fan, L., Miao, Z., Zhu, Y.	2013
129	Opportunity-to-learn context-based tasks provided by mathematics textbooks (Wijaya et al., 2015)	Wijaya, A., van den Heuvel-Panhuizen, M., Doorman, M.	2015
129	A comparative analysis of the addition and subtraction of fractions in textbooks from three Countries (Charalambous et al., 2010)	Charalambous, C.Y., Delaney, S., Hsu, H., Mesa, V.	2010
74	Textbook research as scientific research: Towards a common ground on issues and methods of research on mathematics textbooks (Fan, 2013a)	Fan , L.	2013
62	An Analysis of Problem-Posing Tasks in Chinese and US Elementary Mathematics Textbooks (Cai & Wang, 2017)	Cai, J., Jiang, C	2017
55	Urgency of Higher Order Thinking Skills (HOTS) Content Analysis in Mathematics Textbook (Pratama & Retnawati, 2018)	Pratama, G.S., Retnawati, H.	2018
51	Opportunities to learn: Mathematics textbooks and students' achievements (Hadar et al., 2017)	Hadar, L.L.	2017
50	"Variation problems" and their roles in the topic of fraction division in Chinese mathematics textbook examples (Sun, 2011)	Sun, X.	2011
45	Requirements in mathematics textbooks: a five-dimensional analysis of textbook exercises and examples (Glasnovic Gracin, 2018)	Glasnovic Gracin, D.	2018
40	A comparative analysis of the distributive property in U.S. and Chinese elementary mathematics textbooks (Ding & Li, 2010)	Ding, M., Li, X.	2010

Table 3 presents the 10 most cited documents from 2010–2025, which provide a foundational guide for comparative mathematics textbook research. These top-cited works constitute central references that underpin numerous subsequent studies, particularly due to their contribution in providing a foundational framework for mathematics textbook analysis (Fan et al., 2013). Collectively, these ten articles offer theoretical overviews, methodological frameworks, and examples of empirical studies. Therefore, this list can be legitimately considered an essential reference guide for researchers intending to delve into or contribute to the field of comparative mathematics textbook research.

5. Recommendations for Future Research

As the volume of research and publications on comparative mathematics textbooks continues to increase, future researchers are encouraged to pursue innovative and relevant lines of inquiry that address current issues in mathematics education. This bibliometric analysis has highlighted several under-explored areas, including the integration of mathematics with programming and digital technology, and the linguistic analysis of concept presentation in textbooks. There is also a clear need to expand research into the moral and social values embedded in textbooks, an aspect deemed influential in shaping students' worldviews in several national contexts (Daher, 2021). This study's scope is limited to papers indexed in Scopus from 2010 to 2024, meaning other relevant literature was not included. Despite this limitation, the identification of the top ten most-cited researchers and documents offers the scholarly community a reliable foundation. It is hoped that this information can be leveraged to inform future research trajectories and ultimately have a meaningful impact on the development of mathematics education.

D. CONCLUSION AND SUGGESTIONS

This research reveals a significant expansion in the comparative analysis of mathematics textbooks between 2010 and 2024, a field predominantly led by developed countries like the United States, Korea, and Turkey, indicative of the impact of their educational policy and curriculum reforms. The study also finds that the field has broadened its publication scope, moving beyond specialized journals to embrace a more multidisciplinary platform. From a thematic perspective, there has been a clear trajectory away from simple structural reviews toward more sophisticated evaluative analyses focusing on content quality, cognitive demand, and their effects on learning outcomes. Mapping of the literature has pinpointed several research gaps, most notably in the areas of linguistic analysis of concept presentation and the examination of social values within textbooks. Moreover, the citation analysis of seminal authors and documents provides a credible, strategic benchmark for the future development of more comprehensive textbooks. Implications of this study offer a set of guidelines designed to guide future research toward achieving novelty in the comparative analysis of mathematics textbooks, thereby contributing to more effective mathematics learning

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