Contextual Teaching and Learning in Elementary Mathematics Education: A Bibliometric Performance Analysis

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Abstract
Research on Contextual Teaching and Learning (CTL) in elementary mathematics education has expanded substantially over the past decade, yet no bibliometric study has systematically mapped its intellectual structure, growth pattern, or geographic distribution. This study addresses that gap through a bibliometric performance analysis of 55 Scopus-indexed documents published between 2009 and 2026, guided by three research questions on publication trends, geographic contributions, and source characteristics. Data were retrieved from the Scopus database on May 2, 2026, and analyzed using the Scopus Analyze Search Results feature and Microsoft Excel. Results reveal that annual output grew from one document in 2009 to a peak of 11 in 2020 (20.0% of total), declined to two in 2022 amid COVID-19 disruptions, and resurged to 10 in 2025, the second highest on record. Geographically, Indonesia accounts for 85.5% of publications (n = 47), followed by Malaysia (5.5%; n = 3), while contributions from Western countries and other regions remain negligible. Publication sources are dominated by conference proceedings: the Journal of Physics: Conference Series (36.4%) and AIP Conference Proceedings (20.0%) together account for 56.4% of all documents. These findings highlight the need for broader international collaboration, stronger journal-based dissemination, and expanded use of advanced bibliometric tools.

1. Introduction

Quantitative reasoning and mathematical problem-solving rank among the most consequential competencies formal schooling is expected to develop (Hiebert & Grouws, 2007; Kilpatrick et al., 2001; NCTM, 2000). International assessments persistently reveal that a majority of students fail to reach baseline mathematical proficiency (OECD, 2023). Schoenfeld (2016) contends that this underperformance reflects instructional design rather than cognitive limitation: curricula prioritizing procedural execution over conceptual sense-making deprive students of opportunities to experience mathematics as meaningful (Boaler, 2016; Van de Walle et al., 2019). Addressing this gap demands frameworks that ground mathematical content in contexts students recognize as relevant and purposeful (English, 2016; Tokac et al., 2019).

In elementary mathematics education, Contextual Teaching and Learning (CTL) has emerged as an important pedagogical framework for bridging abstract mathematical concepts with students' lived experiences. Piaget (1973) argued that children construct knowledge through concrete engagement, while Vygotsky (1978) emphasized higher-order thinking through socially mediated and culturally meaningful contexts. Dewey's (1938) principle that education must be rooted in experience and Bruner's (1966) discovery learning both anticipate CTL as a systematic approach connecting academic content to authentic real-world situations (Johnson, 2002; Crawford, 2001). In this perspective, contextually embedded mathematics instruction reduces cognitive load, strengthens motivation, and improves knowledge retention among elementary learners (Kosko & Wilkins, 2010; Siegler et al., 2012; Radford, 2021).

CTL operationalizes these principles through seven core components: making connections, doing significant work, self-regulation, collaboration, critical thinking, nurturing the individual, and reaching high standards (Johnson, 2002; Berns & Erickson, 2001). Grounded in Vygotsky's (1978) zone of proximal development, Piaget's (1973) constructivism, and Freudenthal's (1991) Realistic Mathematics Education (RME), further elaborated by Treffers (1987) and Gravemeijer and Doorman (2008), CTL positions learners as active constructors of knowledge whose cultural experiences serve as meaningful mathematical resources (Hull & Schultz, 2002; CORD, 2007; Sullivan & McDonough, 2007). Empirical studies have demonstrated that CTL contributes to improved mathematical achievement (Laurens et al., 2018; Tamur et al., 2020; Habib et al., 2021), enhances critical thinking abilities (Lestari et al., 2021; Toheri et al., 2020; Sumirattana et al., 2017), increases student engagement (Mentari & Syarifuddin, 2020; Yuanita et al., 2018), and supports the integration of

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ethnomathematical perspectives into mathematics learning (Lidinillah et al., 2022; Samo et al., 2018; Rosa & Orey, 2016).

The importance of CTL in elementary mathematics has stimulated substantial research development across various educational contexts. CTL research has expanded considerably in Southeast Asia, particularly Indonesia, where the PMRI reform institutionalized CTL-aligned principles (Sembiring et al., 2010; Jupri & Drijvers, 2016). Subsequent studies have investigated CTL implementation through diverse perspectives, including the development and validation of CTL-based learning tools (Retnawati et al., 2020; Yohannes & Chen, 2021), integration with ethnomathematics (Lidinillah et al., 2022; Rosa & Orey, 2016), incorporation of educational technology (Fabian & Topping, 2019; Hwang & Tu, 2021; Ekowati et al., 2022), and collaborative mathematical problem-solving approaches (Johar et al., 2020; Schoenfeld, 2016). These developments indicate that CTL has become an increasingly significant research domain within mathematics education, particularly in efforts to promote meaningful, relevant, and student-centered learning.

However, despite the growing number of empirical investigations, previous studies have primarily focused on evaluating instructional effectiveness, developing learning models, or examining specific implementation contexts. The field still lacks a comprehensive quantitative overview that identifies publication trends, geographical distribution, influential sources, research productivity, and emerging thematic structures related to CTL in elementary mathematics education (Marczewska & Kostrzewski, 2020; Zupic & Cater, 2015; Donthu et al., 2021). Existing reviews have not sufficiently mapped the intellectual landscape and evolution of CTL research using systematic bibliometric approaches. Consequently, the overall trajectory, collaboration patterns, and research priorities within CTL-based elementary mathematics remain insufficiently understood.

Bibliometric performance analysis provides an appropriate methodological approach for addressing this limitation by mapping the structural characteristics, productivity patterns, and growth dynamics of scientific fields (Pritchard, 1969; Zupic & Cater, 2015; Donthu et al., 2021). Bibliometric tools such as VOSviewer (Van Eck & Waltman, 2010) and Bibliometrix (Aria & Cuccurullo, 2017) enable researchers to examine publication performance, citation networks, collaboration structures, and thematic developments. Previous bibliometric studies have successfully explored educational leadership (Kulophas & Hallinger, 2020), workplace learning (Huang & Liew, 2021; Moosa & Shareefa, 2020), and mathematics education (Abdelfatah, 2011; Hwang & Tu, 2021; Radford et al., 2022). Nevertheless, the specific relationship between CTL and elementary mathematics education remains unmapped.

Therefore, this study aims to provide a comprehensive bibliometric analysis of research on Contextual Teaching and Learning in elementary mathematics education. Using 55 Scopus-indexed documents published between 2009 and 2026, this study seeks to identify research development patterns and answer the following research questions: (R1) How has the distribution of CTL in elementary mathematics publications developed over time? (R2) How does geographic distribution reflect global development? (R3) Which publication sources and subject areas are most prominent?

2. Method

2.1. Research Design

This study employs bibliometric performance analysis, measuring scientific productivity and scholarly influence within a knowledge domain (Marczewska & Kostrzewski, 2020; Zupic & Cater, 2015). First defined by Pritchard (1969), bibliometrics evolved through Ellegaard & Wallin (2015) and Donthu et al. (2021) into a rigorous instrument for mapping field structure and growth. Performance analysis asks who produces what, where, when, and how much rather than synthesizing study content (Zupic & Cater, 2015; Kulophas & Hallinger, 2020). Seven dimensions are examined: publication year, country, subject area, author productivity, source, document type, and citation impact. The research steps are illustrated in Figure 1.

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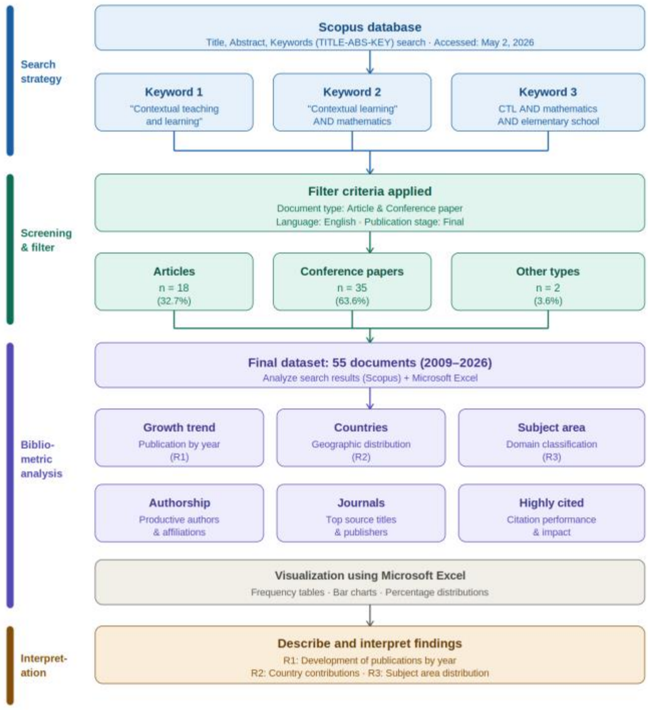

Figure 1. Research Steps of Bibliometric Performance Analysis on CTL in Mathematics Education

2.2. Source of Information and Search Strategy

Data were retrieved from the Scopus database (www.scopus.com) on May 2, 2026, selected for its comprehensive multi-disciplinary coverage (Ellegaard & Wallin, 2015; Donthu et al., 2021). The search string applied in the TITLE-ABS-KEY field was:

> TITLE-ABS-KEY (("contextual teaching and learning" OR "contextual learning" OR "CTL") AND ("mathematics" OR "mathematics education") AND ("elementary" OR "primary school" OR "elementary school"))

The complete input codes for each keyword variation are provided in Table 1.

Table 1. Input Code for Each Keyword

Keyword	Input Code
Contextual Teaching and Learning	TITLE-ABS-KEY("contextual teaching and learning") AND (LIMIT-TO(PUBSTAGE,"final")) AND (LIMIT-TO(DOCTYPE,"ar") OR LIMIT-TO(DOCTYPE,"cp")) AND (LIMIT-TO(LANGUAGE,"English"))
Contextual Learning in Mathematics	TITLE-ABS-KEY("contextual learning" AND "mathematics") AND (LIMIT-TO(PUBSTAGE,"final")) AND (LIMIT-TO(DOCTYPE,"ar") OR LIMIT-TO(DOCTYPE,"cp")) AND (LIMIT-TO(LANGUAGE,"English"))
CTL in Elementary/Primary School	TITLE-ABS-KEY(("contextual teaching and learning" OR "contextual learning" OR "CTL") AND ("mathematics" OR "mathematics education") AND ("elementary" OR "primary school")) AND (LIMIT-TO(PUBSTAGE,"final")) AND (LIMIT-TO(DOCTYPE,"ar") OR LIMIT-TO(DOCTYPE,"cp")) AND (LIMIT-TO(LANGUAGE,"English"))

2.3. Inclusion and Exclusion Criteria

Documents were included if: (1) indexed in Scopus with full metadata, (2) published in English, (3) with final publication status, and (4) classified as journal articles or conference papers. The final dataset and filtering results are summarized in Table 2.

Table 2. Summary of Document Selection by Keyword

Keyword	Initial Results	Article	Conf. Paper	Final (EN)
Contextual Teaching and Learning	n = 127	18	35	55
Contextual Learning + Mathematics	n = 89	—	—	(merged)
CTL + Elementary/Primary School	n = 55	—	—	55 (final)

The final dataset comprised 18 journal articles (32.7%), 35 conference papers (63.6%), and 2 other document types (3.6%), spanning 2009 to 2026.

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2.4. Tools and Statistical Analysis

The Scopus "Analyze search results" feature served as the primary extraction tool, generating frequency distributions by year, country, author, source, and subject area. Microsoft Excel was used for data organization, percentage calculations, and chart generation, consistent with established bibliometric practice (Marczewska & Kostrzewski, 2020; Moosa & Shareefa, 2020). Advanced tools including VOSviewer (Van Eck & Waltman, 2010) and Bibliometrix (Aria & Cuccurullo, 2017) are recommended for future co-authorship and keyword co-occurrence mapping.

3. Results and Discussion

Findings are organized around R1, R2, and R3, supplemented by author productivity and citation impact analyses.

3.1. Development of Distribution of Publications by Year

The 55 documents exhibit a three-phase trajectory. During the emergence phase (2009–2016), output was minimal: one document each in 2009 and 2011, reflecting early concentration in practitioner-oriented non-indexed venues (Johnson, 2002; Jupri & Drijvers, 2016). The full distribution is shown in Table 3 and Figure 2.

Table 3. Distribution of publications by year (2009–2026)

Year	Documents	(%)	Remarks
2009	1	1.8	First publication recorded in Scopus
2011	1	1.8	Single publication; limited early interest
2017	3	5.5	Research begins to gain momentum
2018	7	12.7	Significant growth; 7× increase from 2009
2019	8	14.5	Continued upward trend
2020	11	20.0	Peak year — highest publication volume
2021	3	5.5	Decline; COVID-19 disruption
2022	2	3.6	Lowest since 2017
2024	4	7.3	Recovery phase begins
2025	10	18.2	Second highest; strong resurgence
2026	5	9.1	Ongoing — year not yet complete at retrieval
Total	55	100	

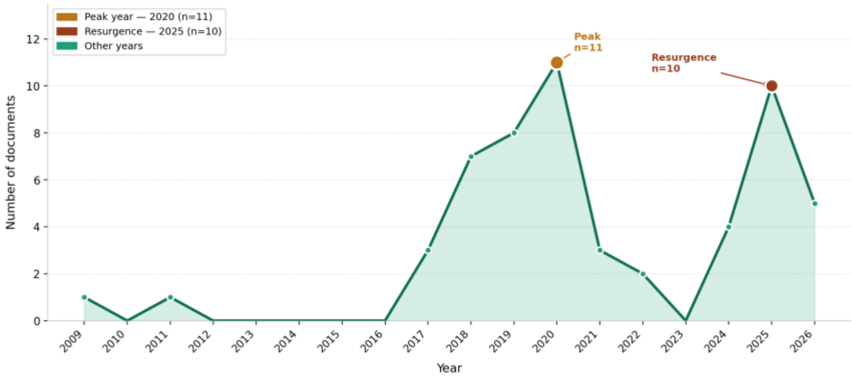

Figure 2. Publication Trend of CTL in Elementary Mathematics Education (2009–2026)

The growth phase (2017–2020) accelerated from three publications in 2017 to a peak of 11 in 2020 (20.0%), driven by PMRI curriculum formalization in Indonesia (Sembiring et al., 2010; Yohannes & Chen, 2021) and institutional publication pressure (Wahyudi & Winanto, 2020; Tamur et al., 2020). The disruption phase (2021–2022) saw output decline to three and two documents respectively, consistent with COVID-19's global impact (Fabian & Topping, 2019; Radford, 2021). The recovery phase (2024–2026) produced four, ten, and five publications respectively, confirming sustained momentum (Donthu **et al., 2021; Boaler, 2016).**

3.2. Development of Research by Country

Indonesia contributes 85.5% (n = 47), followed by Malaysia at 5.5% (n = 3), with Spain, Egypt, and the United Kingdom contributing one document each (1.8%) (Table 4; Figure 3). Indonesia's dominance reflects PMRI curriculum institutionalization (Sembiring et al., 2010) and rapid Scopus output growth (Wahyudi & Winanto, 2020; Retnawati et al., 2020).

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Table 4. Distribution of Publications by Contributing Country

Country	Documents	(%)	Region
Indonesia	47	85.5	Southeast Asia — Dominant contributor
Malaysia	3	5.5	Southeast Asia — Second contributor
Spain	1	1.8	Western Europe
Egypt	1	1.8	Africa
United Kingdom	1	1.8	Western Europe
Total	53	96.4	

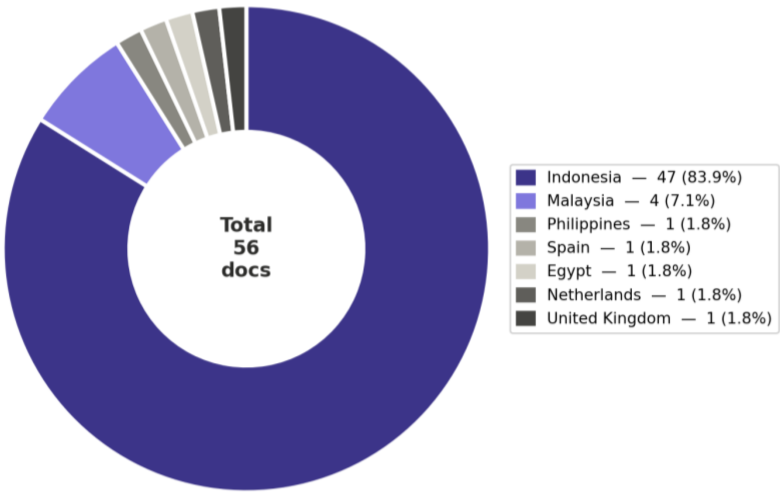

Figure 3. Geographic Distribution of Publications on CTL in Elementary Mathematics Education

The near-complete absence of Western contributions is significant: contextual approaches are globally advocated (NCTM, 2000; OECD, 2023; Hiebert & Grouws, 2007; Schoenfeld, 2016; Radford, 2021), yet have not translated into CTL-labeled bibliometric output. Future studies should examine contextual mathematics practices in Africa, Europe (Prediger et al., 2016; Meaney et al., 2012), and Latin America.

3.3. Development of Research Based on Subject Area and Publication Source

The Journal of Physics: Conference Series (36.4%) and AIP Conference Proceedings (20.0%) account for 56.4% of all publications (Table 5; Figure 4). This conference proceedings dominance is consistent with bibliometric findings in developing-country education research (Moosa & Shareefa, 2020; Marczewska & Kostrzewski, 2020; Ekowati et al., 2022), signaling a knowledge broadcast phase rather than rigorous peer-reviewed consolidation (Ellegaard & Wallin, 2015; Donthu et al., 2021). Future work should target Educational Studies in Mathematics, Journal on Mathematics Education, and Eurasia Journal of Mathematics, Science and Technology Education (Gravemeijer & Doorman, 2008; Radford et al., 2022).

Table 5. Top Publication Sources for CTL in Elementary Mathematics Education Research

Source Title	Documents	(%)	Type & Publisher
Journal of Physics: Conference Series	20	36.4	Conference — IOP Publishing
AIP Conference Proceedings	11	20.0	Conference — AIP Publishing
Multidisciplinary Science Journal	3	5.5	Journal — Multidisciplinary
European Journal of Educational Research	2	3.6	Journal — Education
Journal of Education & e-Learning Research	2	3.6	Journal — Education
Journal on Mathematics Education	2	3.6	Journal — Math Education
Others (1 paper each)	15	27.3	Various journals & proceedings

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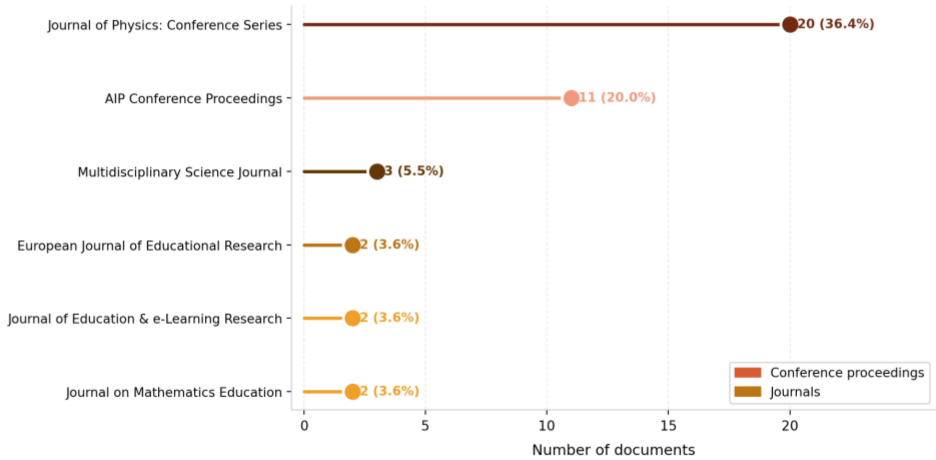

Figure 4. Top Publication Sources for CTL in Elementary Mathematics Education Research

3.4. Productive Authors and Institutional Affiliation

Sugiman (Universitas Negeri Yogyakarta) leads with three publications; seven others contributed two each (Table 6; Figure. 5). All productive authors are affiliated with Indonesian or Malaysian public universities. The absence of any author with four or more publications indicates a field without dominant anchor scholars (Zupic & Cater, 2015; Donthu et al., 2021). International co-authorship would broaden theoretical foundations and citation reach (Johar et al., 2020; Meaney et al., 2012; Rosa & Orey, 2016).

Table 6. Most Productive Authors in CTL in Elementary Mathematics Education Research

No	Author	Affiliation	Country	Docs
1	Sugiman	Universitas Negeri Yogyakarta	Indonesia	3
2	Retnawati, H.	Universitas Negeri Yogyakarta	Indonesia	2
3	Johar, R.	Universitas Syiah Kuala	Indonesia	2
4	Fiangga, S.	Universitas Negeri Surabaya	Indonesia	2
5	Masduki	Univ. Muhammadiyah Surakarta	Indonesia	2
6	Abdullah, A.H.	Universiti Teknologi Malaysia	Malaysia	2
7	Ibrahim, N.H.	Universiti Teknologi Malaysia	Malaysia	2
8	Samo, D.D.	Universitas Flores	Indonesia	2

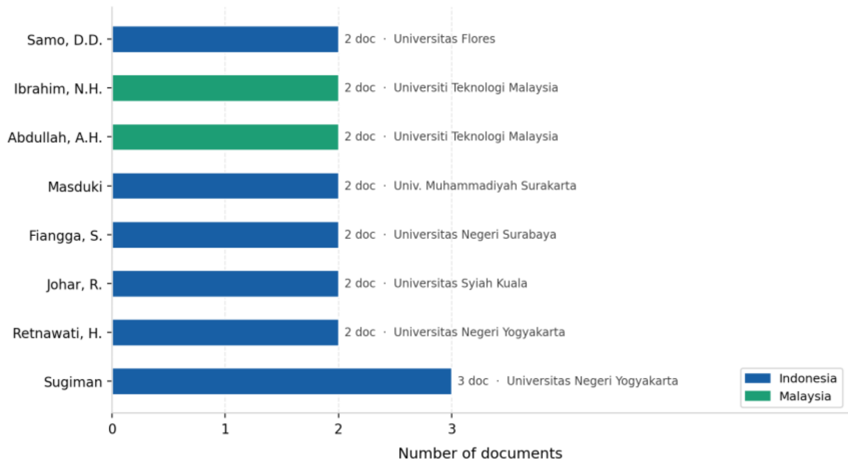

Figure 5. Most Productive Authors in CTL in Elementary Mathematics Education Research

3.5. High Cited Articles

Laurens et al. (2018) leads with 147 citations, demonstrating that RME — closely related to CTL (Freudenthal, 1991; Treffers, 1987; Gravemeijer & Doorman, 2008) — significantly improves mathematical achievement. Fabian & Topping (2019) ranks second (41 citations) on mobile technology integration (Hwang & Tu, 2021; Tokac et al., 2019). Toheri et al. (2020) ranks third (37 citations), confirming contextual learning's advantage in critical thinking development (Bruner, 1966; Sumirattana et al., 2017). The full ranking is presented in Table 7.

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Table 7. Top 10 Most Highly Cited Articles in CTL in Elementary Mathematics Education Research

No	Title	Author(s)	Year	Cited
1	How does realistic mathematics education (RME) improve students' mathematics cognitive achievement?	Laurens et al.	2018	147
2	Putting "mobile" into mathematics: Results of a randomised controlled trial	Fabian & Topping	2019	41
3	Where exactly for enhance critical and creative thinking: The use of problem posing or contextual learning	Toheri et al.	2020	37
4	Contextual Teaching and Learning Approach of Mathematics in Primary Schools	Selvianiresa & Prabawanto	2017	29
5	Culture-based contextual learning to increase problem-solving ability of first year university student	Samo et al.	2018	29
6	Integrating Sundanese Ethnomathematics into Mathematics Curriculum and Teaching	Lidinillah et al.	2022	29
7	The implementation of mathematics comic through contextual teaching and learning	Utami et al.	2021	28
8	Designing Mathematics Learning Models Based on Realistic Mathematics	Johar et al.	2020	24
9	Development of learning tools based on contextual teaching and learning	Retnawati et al.	2020	22
10	Assessing the effectiveness of the contextual teaching and learning model	Tamur et al.	2020	16

Three citation clusters emerge: (1) realistic and contextual learning (Laurens et al., 2018; Gravemeijer & Doorman, 2008; Sembiring et al., 2010; Jupri & Drijvers, 2016), (2) ethnomathematical integration (Lidinillah et al., 2022; Rosa & Orey, 2016; Meaney et al., 2012; Yohannes & Chen, 2021), and (3) technology-enhanced CTL (Fabian & Topping, 2019; Hwang & Tu, 2021; Lestari et al., 2021; Ekowati et al., 2022), aligning with 21st-century mathematical literacy demands (Kilpatrick et al., 2001; Boaler, 2016; OECD, 2023; Radford, 2021).

3.6. Implications for Educational Research

The findings of this bibliometric performance analysis provide several important implications for educational research, particularly in the field of elementary mathematics education. First, the study offers a comprehensive overview of the development, trends, and intellectual structure of research on Contextual Teaching and Learning (CTL) in mathematics education. By identifying publication patterns, influential authors, leading institutions, productive countries, and dominant research themes, this study helps researchers better understand the current state of knowledge and emerging directions within the field. Such information can serve as a valuable reference for designing future studies and identifying underexplored research areas.

The results also indicate that CTL continues to be widely recognized as a promising pedagogical approach for enhancing students' conceptual understanding, problem-solving abilities, mathematical literacy, and learning engagement. However, the bibliometric mapping reveals that certain themes remain insufficiently explored, particularly those related to the integration of CTL with digital technologies, artificial intelligence, inclusive education, differentiated instruction, and 21st-century skills development. These gaps present opportunities for future researchers to expand the scope of CTL studies and investigate its effectiveness in addressing contemporary educational challenges.

Furthermore, the findings highlight the importance of strengthening international collaboration among researchers in mathematics education. The concentration of publications within specific countries and institutions suggests that broader collaborative networks could facilitate the exchange of ideas, methodological innovations, and contextual perspectives. Future research should therefore encourage cross-national and interdisciplinary collaborations to generate more diverse and comprehensive evidence regarding the implementation of CTL in various educational settings.

In addition, the bibliometric results suggest that future studies should move beyond examining learning outcomes alone and explore the mechanisms through which CTL influences students' cognitive, affective, and social development. Investigating variables such as critical thinking, creativity, self-regulated learning, mathematical resilience, and student motivation may contribute to a deeper understanding of the broader educational impact of contextual learning approaches. Consequently, this study provides a foundation for developing more innovative and evidence-based research agendas in elementary mathematics education.

3.7. Limitations

Several limitations should be acknowledged when interpreting the findings of this bibliometric study. First, the analysis was limited to publications indexed in selected academic databases. Although these databases contain a substantial number of high-quality scholarly publications, relevant studies published in other databases, conference proceedings, institutional repositories, books, or non-indexed journals may not have been included. As a result, the findings may not fully represent the entire body of literature on Contextual Teaching and Learning in elementary mathematics education.

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Second, bibliometric analysis primarily focuses on quantitative publication indicators such as publication counts, citation frequencies, authorship networks, and keyword occurrences. While these indicators provide valuable insights into research productivity and scholarly influence, they do not directly assess the methodological quality, theoretical rigor, or practical effectiveness of the studies analyzed. Therefore, highly cited publications should not automatically be interpreted as representing the strongest empirical evidence.

Another limitation concerns the dynamic nature of scientific publications. Research trends, citation patterns, and collaboration networks continuously evolve as new studies are published. Consequently, the findings presented in this study reflect the state of the literature during the selected period of analysis and may change over time as the field develops further.

Finally, the interpretation of keyword co-occurrence networks and thematic clusters involves a degree of subjectivity. Although bibliometric software provides objective visualizations of relationships among research topics, the labeling and interpretation of thematic patterns depend on the researcher's judgment. Future studies may complement bibliometric approaches with systematic literature reviews or meta-analyses to provide a more comprehensive understanding of the theoretical and empirical development of Contextual Teaching and Learning in elementary mathematics education.

4. Conclusion

Three findings characterize the current state of CTL research in elementary mathematics education. Publication output grew from 2009, peaked at 11 documents in 2020, contracted during COVID-19, and recovered strongly to 10 in 2025, signaling sustained scholarly investment (Donthu et al., 2021; Zupic & Cater, 2015). Geographically, Indonesia accounts for 85.5% and Malaysia 5.5% of all Scopus-indexed publications, reflecting PMRI curriculum integration (Sembiring et al., 2010) but signaling an urgent need for international engagement (NCTM, 2000; OECD, 2023; Radford, 2021). Dissemination is dominated by conference proceedings (56.4%), limiting cumulative citation impact and international visibility (Ellegaard & Wallin, 2015; Moosa & Shareefa, 2020). This study contributes the first comprehensive bibliometric mapping of CTL in elementary mathematics education. Citation analysis identifies Laurens et al. (2018) as the most influential work and reveals three generative thematic clusters: contextual/realistic learning (Freudenthal, 1991; Gravemeijer & Doorman, 2008), ethnomathematics (Rosa & Orey, 2016; Lidinillah et al., 2022), and technology integration (Fabian & Topping, 2019; Hwang & Tu, 2021; Ekowati et al., 2022). Future research should: (1) broaden geographic scope (Meaney et al., 2012; Prediger et al., 2016); (2) target high-impact indexed journals (Donthu et al., 2021); (3) build international research networks; (4) explore CTL-technology-ethnomathematics intersections (Boaler, 2016; Van de Walle et al., 2019); and (5) apply VOSviewer (Van Eck & Waltman, 2010) and Bibliometrix (Aria & Cuccurullo, 2017) for network-level analysis.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/ or publication of this article.

Data Availability

The datasets generated during and/ or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript.

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