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Journal of General Education and Humanities
Vol. 5, No. 1, February 2026, pp. 49 – 59, https://doi.org/10.58421/gehu.v5i1.740
ISSN 2963-7147

Mathematical Connection Research in Indonesia: A Bibliometric Study (2020–2025)

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Article Info

Article history:

Received 2025-10-01
Revised 2025-10-31
Accepted 2025-11-03

Keywords:

Bibliometric
Indonesia
Mathematical connection
Mathematics education
Research trends

ABSTRACT

This study aims to analyze the development of publications on mathematical connections in Indonesia from 2020 to 2025. A total of 91 articles were analyzed using a bibliometric approach based on metadata obtained from Google Scholar, SINTA, and national journal databases. The analysis focused on annual publication trends, productive journals and their indexation status, research methods, educational levels examined, and dominant keywords. The findings show an increase in publications over the last five years, especially in 2023–2024. Most articles were published in national journals indexed by SINTA, while publications in international indexed journals remain limited. The dominant research method was qualitative-descriptive (52 articles), followed by quantitative (22 articles), mixed methods (5 articles), R&D (5 articles), and literature review (7 articles). Junior high school/MTs was the most researched education level, with 47 articles, followed by high school with 34, while research at the elementary and higher education levels was still limited. The most dominant keywords used were mathematical connections and mathematical connection ability, along with problem-solving and contextual learning. This study highlights mathematical connections as an important focus in mathematics education research in Indonesia and suggests further exploration across varied education levels and methodologies.

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1. INTRODUCTION

Mathematics plays a central role in developing the skills of logical reasoning, analytical thinking, and problem-solving that are needed to address real-life problems [1], [2]. However, Indonesian students' mathematics achievement remains below international standards. According to the Programme for International Student Assessment (PISA), Indonesia's mathematics score declined from 379 in 2018 to 366 in 2022, lagging far behind

the OECD average [3], [4], [5]. This condition reflects students' weak ability to connect mathematical concepts to real-world contexts [6].

One crucial skill for supporting students' conceptual understanding and high-level thinking is making mathematical connections. NCTM defines this ability as the ability to relate mathematical ideas, procedures, and concepts, both internally across topics and externally to other disciplines and to daily life [7], [8]. Various studies report that the mathematical connection skills of Indonesian students remain low and tend to focus on procedures rather than on the interconnectedness of concepts [9], [10], [11].

Several learning approaches have been developed to improve these abilities, such as problem-based learning [12], discovery learning [13], and contextual approaches [14]. However, systematic mapping of research on mathematical connections in Indonesia remains limited. Questions about the most frequently researched level of education, the dominant research methods, and the themes or keywords that appear most often have not been answered thoroughly.

Bibliometrics is the right approach to obtain a comprehensive overview of the development of research in a field [15] Previous bibliometric studies on mathematics education have been conducted, for example on the topic of mathematical communication [16] and constructivist approaches to geometry learning [17] However, until now, bibliometric studies that specifically highlight mathematical connections in Indonesia are still very limited. This is where the novelty of this research lies.

Based on these gaps, this study aims to analyze publications on mathematical connections in Indonesia for the period 2020-2025 through a bibliometric approach. The analysis is focused on the following five aspects:

a. Annual publication trends,
b. Productive journals and indexing status,
c. The research method used,
d. The level of education studied, and
e. The dominant keywords in the publication.

This research is limited to 91 articles obtained manually, but is expected to provide a comprehensive overview of the development of mathematical connection research in Indonesia and to serve as a reference for future research.

2. METHOD

This study uses the bibliometric analysis method, a quantitative approach often used to analyze bibliographic data in scientific articles and journals [15], [18]. Data will be collected in February 2025 from several publicly accessible databases, namely Google Scholar through the Publish or Perish application, the SINTA (Science and Technology Index) portal, Open Knowledge, and Scopus. The search process is manual because not all national journals provide metadata that supports automated searches, so manual searching is necessary to achieve more comprehensive data coverage.

Article searches were conducted using the keywords "mathematical connection," "mathematical connection ability," and "mathematical connection." The articles obtained were then selected based on inclusion criteria: published between 2020 and 2025, focused

on mathematics education, published as journal articles, and open access. Irrelevant articles, proceedings, or duplicates from various databases are identified and removed during the selection process. After screening, 91 articles met the analysis criteria.

The metadata of each article includes the title, author, journal, year of publication, indexation status (SINTA, Scopus, or unindexed), research method, level of education studied, number of keywords, and citations. The analysis was conducted quantitatively and descriptively to identify publication trends, productive journals, methodological approaches, the educational level studied, and dominant keywords. Visualization of keyword co-occurrence networks was carried out using VOSviewer to map the patterns of relationships between mathematical connection research themes in Indonesia. All of the articles analyzed came from open-access publications, so this study did not require ethical approval. However, it has limitations, including data coverage limited to publicly available articles obtained through manual search.

3. RESULTS

3.1 Annual Publication Trends

An analysis of 91 articles shows that research on mathematical connections in Indonesia has increased throughout the 2020–2025 period. The highest number of publications occurred in 2024 (28 articles), while in 2025, the number is still low (6 articles) because the data only covers publications through February 2025. The publication shows a trend that has been increasing year by year, especially in 2023 and 2024.

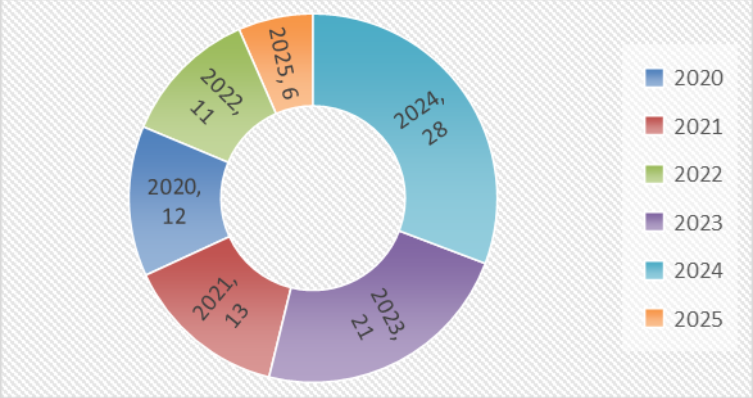

Figure 1. Annual Publication Trends on Mathematical Connection Research (2020–2025). Data source: authors' dataset compiled from Publish or Perish (Google Scholar), Open Knowledge, and SINTA.

3.2 Productive Journals and Indexing Status

Based on classification, the journal that published the most articles on mathematical connections was Jurnal Cendekia: Jurnal Pendidikan Matematika with 11 articles and 86 citations. Other fairly productive journals include Jurnal Pendidikan Matematika (SINTA 2, 4 articles, 66 citations), Journal of Mathematics Education Sigma (JMES) (3 articles, 55 citations), and PRISMA (3 articles, 35 citations). In addition, there are articles published in reputable international journals, namely the Journal on Mathematics Education (JME), which is indexed in Scopus Q2 and SINTA 1, although the number is limited. This indicates

that publications on mathematical connections are still dominated by national journals indexed in SINTA, while contributions to international journals remain limited.

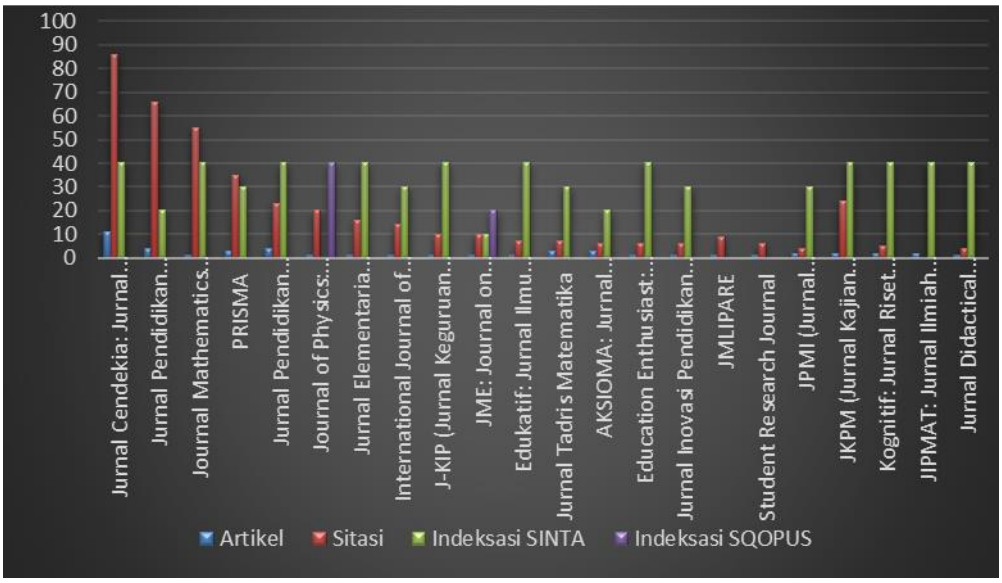

Figure 2. Journal Productivity, Citation Counts, and Indexing Status in Mathematical Connection Research (2020–2025). Source: authors' dataset.

3.3 Dominant Research Methods

Based on the classification of research methods, research on mathematical connections in Indonesia is dominated by qualitative approaches, with 52 articles. This indicates that most researchers prefer to explore the phenomenon of mathematical connections in depth through descriptive analysis of students' thinking processes. Meanwhile, quantitative research only amounted to 22 articles, which generally focused on measuring mathematical connection abilities using test instruments or learning experiments. Mixed-methods approaches were reported in 5 articles, indicating that efforts to integrate numerical analysis with qualitative descriptions to examine mathematical connections remain limited. In addition, five studies used a research and development (R&D) model, which generally produced learning tools to support the improvement of mathematical connections, and seven articles were literature reviews that attempted to map the conceptual development of mathematical connection research.

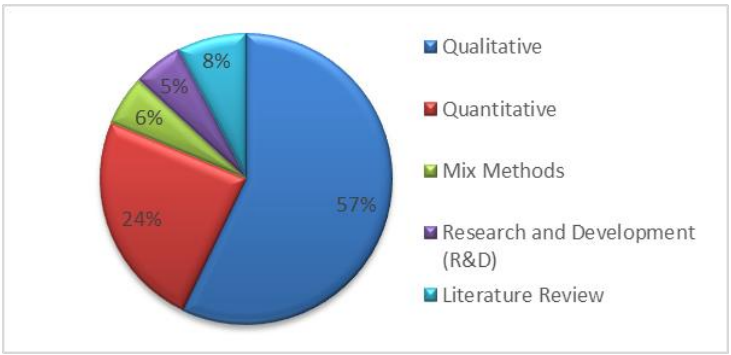

Figure 3. Frequency of Dominant Keywords in Mathematical Connection Research (2020–2025). Source: authors' dataset.

3.4 Educational Levels Studied

In terms of education level, research on mathematical connections has mostly focused on junior high school/MTs level, with a total of 47 articles. This aligns with the idea that students in the first stage of secondary education are at a crucial stage in developing their ability to connect mathematical concepts. At the high school/equivalent level, 34 articles emphasize the connection between mathematics and more complex material, such as quadratic functions, probability, and geometry. Research at the university level is relatively scarce, with only five articles, even though, at this level, mathematical connections are important for supporting cross-disciplinary understanding. Research at the elementary school level is even more limited, with only four articles, even though the early stage is crucial for developing the ability to connect concepts. In addition, six articles are not tied to a specific level but focus on mapping the theory and practice of developing mathematical connections.

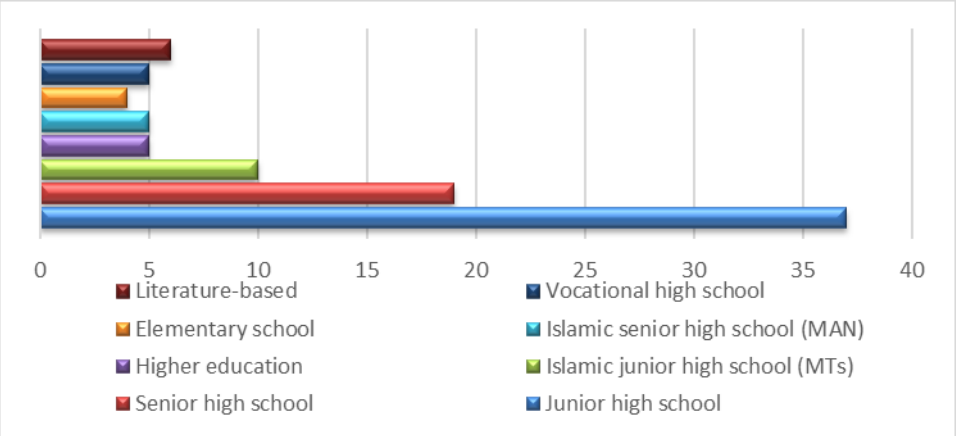

Figure 4. Educational Levels Investigated in Mathematical Connection Research (2020–2025). Source: authors' dataset.

3.5 Dominant Keyword

Metadata analysis also showed that the most dominant keyword was mathematical connection, with a frequency of 63, followed by mathematical connection ability, with a frequency of 38. Problem-solving keywords appeared 12 times, while contextual keywords were recorded 9 times, and analysis appeared 4 times, followed by other keywords such as LKPD, RME, CORE, and Discovery Learning, but with fewer occurrences than the other keywords.

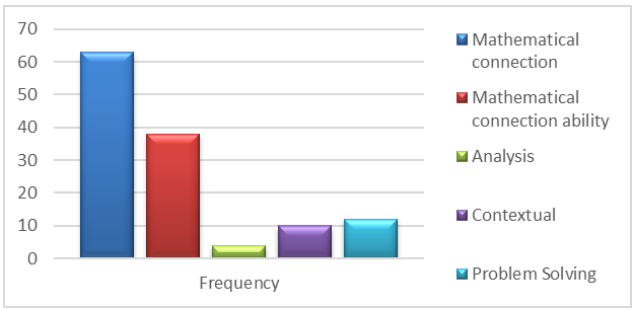

Figure 5. Frequency of Dominant Keywords in Mathematical Connection Research (2020–2025). Source: authors' dataset.

3.6 VOSviewer visualization

The keyword network visualization in Figure 6 shows that the most frequently appearing terms in the dataset are mathematical connection and mathematical connection ability. These keywords highlight the research's central focus: developing students' ability to link mathematical concepts and representations. Other prominent keywords, such as problem solving and contextual, indicate that studies on mathematical connections are closely related to contextual problem-based learning. Several keywords appear with lower frequency, including students' worksheets (LKPD), RME, CORE, analysis, and Discovery Learning, reflecting the diversity of instructional approaches and learning models used by researchers to enhance students' mathematical connection skills.

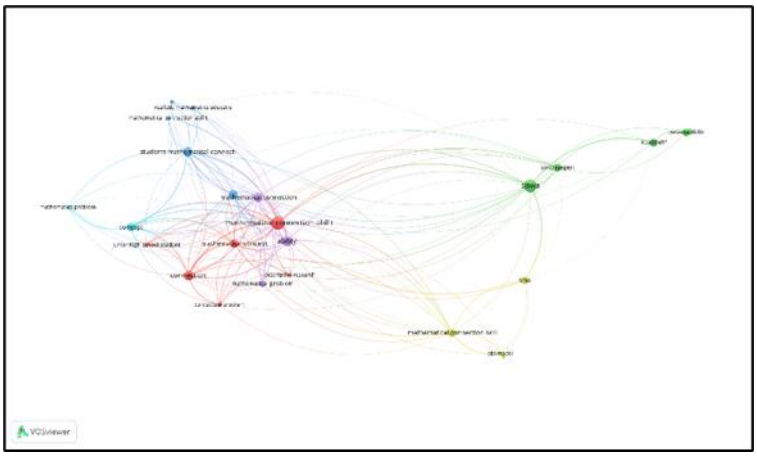

Figure 6. Keyword Co-occurrence Network Visualization (VOSviewer)

Based on the network structure generated by VOSviewer, four keyword clusters were identified, each representing a distinct research orientation. Cluster 1 (red) focuses on conceptual aspects, containing terms such as mathematical connection ability, mathematical concept, connection, and contextual problem. Cluster 2 (blue) centers on students' competencies, with keywords such as students' mathematical connection, mathematical connection ability, and junior high school students. Cluster 3 (green) highlights research contexts, including students, SMP, public junior high school, and qualitative, which shows that most studies were qualitative and centered on junior high school participants. Cluster 4 (yellow) emphasizes instructional models, featuring terms such as mathematical connection skill and PBL model, reflecting studies that examined specific learning approaches to improve students' connection abilities.

The most central nodes connecting all clusters are mathematical connection ability, mathematical connection, and siswa. This network pattern demonstrates the strong relationship between conceptual, student-centered, and instructional perspectives in mathematical connection research conducted in Indonesia.

4. DISCUSSION

4.1 Annual Publication Trends

The increase in publications in 2023-2024 indicates that mathematical connections are increasingly a concern in Indonesian mathematics education research. This surge aligns

with increased research interest in mathematical abilities related to 21st-century skills, such as problem-solving and high-level reasoning [12], [19]. This condition is also a response to the low PISA 2018 and 2022 scores, which indicate the weakness of Indonesian students in connecting mathematical concepts to real-life contexts [3], [5]. This means that the researcher's attention to mathematical connections emerged as an effort to address the challenges posed by national education policy and quality. The implication for education is the need to align research and learning practices that consistently support the development of mathematical connections, not only at the moment of international assessment but also in the curriculum.

4.2 Productive Journals and Indexed Status

The dominance of publications in national journals indexed by SINTA indicates that mathematical connection research has been widely accepted in domestic publications. This is in accordance with the characteristics of educational research, which tend to have a strong local context, so it is published more in national than in international journals [15]. However, the low number of contributions to reputable journals in Scopus indicates a need to improve research methodologies and international collaboration. The practical implication is that mathematics education research policy should direct support toward increasing the capacity of global publications through English-language publication training and strengthening cross-border research networks.

4.3 Dominant Research Methods

The most widely used qualitative method shows that researchers focus more on exploring students' thinking processes in connecting mathematical concepts. This aligns with the characteristics of mathematical connections, which are often studied through the analysis of problem-solving strategies and cognitive observation [20], [21]. However, quantitative and mixed-methods research is still needed to provide stronger empirical evidence on the effectiveness of certain learning models in improving these abilities [9], [10], [22]. Qualitative dominance also indicates that the development of standardized instruments to measure mathematical connections remains limited in Indonesia. The implications for research and policy are the need to improve experimental studies and to develop valid instruments, thereby strengthening the basis for decision-making.

4.4 Educational Levels Studied

The focus of the research, which is dominated by the junior high school/MTs level, can be understood because this stage is a transition period of cognitive development according to Piaget's theory, namely from concrete to formal operations, so that the ability to relate concepts begins to develop more complex [1], [23] The smaller number of studies at the elementary and university levels shows that there is a research gap. In fact, the ability to make mathematical connections needs to be built from the basic stage onward, serving as the foundation for understanding sustainable concepts [24], [25]. In higher education, the limited research has the potential to hinder the integration of mathematical connections into interdisciplinary learning. The implication is that an equal focus on mathematical connection

research is needed at all levels to ensure the continuity of learning from the basic to the higher levels.

4.5 Discussion: Research Themes Based on Keyword and Network Analysis

The analysis of the research theme, based on keywords and networks, shows that research on mathematical connections in Indonesia during 2020-2025 focuses primarily on conceptual understanding and student-oriented learning. The dominance of the keywords mathematical connection and mathematical connection ability indicates that most research aims to strengthen students' ability to connect mathematical concepts across topics and to real-life contexts. This focus aligns with the Principles and Standards for School Mathematics framework, which emphasizes mathematical connections as one of the key process standards in mathematics learning [7].

The emergence of keywords such as problem-solving, contextual, and PBL models emphasizes that the development of mathematical connection skills is widely integrated into problem-based and contextual learning. A similar pattern was also found in several bibliometric studies and systematic literature reviews in the field of mathematics education, which showed that research in Indonesia largely attributed mathematical connections to contextual learning approaches in response to PISA's findings regarding students' weak ability to apply mathematical concepts in real-life situations [3], [4], [5]. This thematic concentration reflects a pedagogical direction that emphasizes meaningful learning through contextualization and students' active involvement in problem-solving.

The clustering results from VOSviewer reinforce this interpretation. The four main clusters that were formed showed different but interconnected research orientations, namely: (1) conceptual studies that focus on the definition and measurement of mathematical connections, (2) empirical studies in the classroom that highlight students' mathematical connection skills, (3) research contexts that are dominated by qualitative approaches at the junior high school level, and (4) the development of learning models such as PBL, CORE, and RME. This pattern shows that mathematics education research in Indonesia tends to focus on classroom-based learning innovations rather than large-scale quantitative analysis or international comparisons [26], [27].

These findings align with research trends in other aspects of mathematics education, such as mathematical communication and mathematical representation, where qualitative-descriptive designs are also more prevalent and context-based interventions are often the main focus [28], [29]. The integration of keywords such as students, qualitative, and junior high school at the central node also indicates that most of the research focuses on middle-level students, an important phase in the cognitive transition from concrete to abstract thinking [30].

Overall, the dominance of qualitative and classroom-based research demonstrates Indonesian researchers' commitment to understanding students' thinking processes in depth in the context of real learning. However, this condition also presents methodological limitations, as collaborative research between institutions and long-term studies remains rare. Therefore, further research is recommended to expand the scope through inter-institutional collaboration and long-term bibliometric analysis to provide a more

comprehensive picture of the development of mathematical connection research in Indonesia [31], [32].

These findings have important implications for the education sector. The dominance of contextual and problem-based themes shows that teachers and curriculum developers are increasingly aware of the importance of linking mathematics to students' daily lives. In addition, the results of this research can serve as a basis for policymakers and researchers to strengthen cross-field collaboration and expand international research, so that the outcomes of mathematics education research in Indonesia are better known and contribute to the development of global learning practices.

5. CONCLUSION

This study describes the development of research on mathematical connections in Indonesia during 2020-2025, based on an analysis of 91 articles. The results show that the number of publications is increasing rapidly in 2023-2024, which means that attention to the topic of mathematical connections is growing in the field of mathematics education. Most articles are published in national journals indexed by SINTA, while publications in international journals remain few.

The most widely used research method is qualitative-descriptive, focusing on how students think and connect mathematical concepts. Research is most often conducted at the junior high school/MTs level, which is an important stage in the development of students' connection skills. Keyword and network analysis also showed that research on mathematical connections is strongly associated with problem-based learning and contextual learning. This shows that the researchers are trying to answer the challenge of students' low mathematical connection ability in Indonesia.

This study has limitations: it uses only openly accessible, manually collected articles, so it may not include all relevant publications. In general, the results of this study confirm that mathematical connections are one of the important focuses in mathematics education in Indonesia. Future research is expected to expand studies at the primary and higher education levels, using quantitative or longitudinal methods, and involve inter-institutional cooperation and cross-border research. This effort is important to improve the quality and influence of Indonesian mathematics education research at the global level.

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