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Mapping Research Trends on Learning Trajectory in Mathematics Education: A Systematic Literature Review and Bibliometric Analysis

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ABSTRACT

This study aims to map global research developments on learning trajectories in mathematics education through a systematic literature review and bibliometric analysis. Data were obtained from the Scopus database, with 1,957 initial records screened and 65 relevant articles analyzed based on predefined inclusion and exclusion criteria to ensure relevance and methodological rigor. Bibliometric mapping using VOSviewer was conducted to visualize the evolution of topics, co-authorship networks, methodological trends, and cross-country dissemination. The findings indicate a notable shift from conceptual discussions to classroom-based implementations, the integration of ethnomathematics, and technology-supported instructional designs that promote contextual and student-centered learning. Furthermore, the analysis identifies four dominant research clusters, namely student thinking pathways, curriculum learning progressions, teacher professional development, and digital learning tools. Indonesia appears as the most productive contributor, driven by PMRI traditions and design research practices, alongside a gradual rise in contributions from other countries. This study contributes to the field by highlighting ethnomathematics and technological innovation as emerging research directions and by providing a conceptual roadmap to guide future investigations. The results offer practical implications for educators and researchers in designing culturally responsive learning pathways that deepen mathematical understanding and align with the demands of 21st-century learning.

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1. INTRODUCTION

Education is a conscious, systematic, and planned effort to improve the quality of human life through the development of potential, character, and intellectual capability [1]. Within this framework, mathematics stands as one of the core disciplines in formal education, playing a crucial role in shaping students' cognitive abilities and twenty-first-

century competencies [2]. These competencies include critical, logical, analytical, and creative thinking, as well as problem-solving skills necessary for navigating increasingly complex global challenges [3]–[6]. Consequently, mathematics learning must undergo a pedagogical shift from traditional teacher-centered instruction toward student-centered learning that actively engages students in the construction of knowledge through meaningful and authentic learning experiences [2], [7], [8]. Such a transformation requires a deep understanding of how students think and learn, making the concept of learning trajectory highly relevant, as it provides teachers with a structured lens to track and anticipate students' progress toward conceptual mastery [9], [10].

A learning trajectory refers to a sequenced progression of learning activities that students experience as they build conceptual understanding, advancing from simple ideas to more complex and abstract reasoning in accordance with their cognitive development [11]–[14]. By comprehending these trajectories, teachers can design instructional strategies that are developmentally appropriate, responsive to students' needs, and oriented toward deeper mathematical understanding [9]. This alignment enables learning environments that are more purposeful, adaptive, and meaningful, while supporting instructional decisions that maximize student growth [2], [15]–[17].

Previous studies have examined learning trajectories from various perspectives, such as classroom implementation, learning design, and student cognitive pathways in specific mathematical topics [11], [13], [14], [17], [18]. However, these studies are fragmented and limited in scope, as they tend to focus on isolated themes and do not provide a comprehensive mapping of the field. As a result, there is still a lack of systematic evidence describing how learning trajectory research has evolved, what themes dominate the discourse, and how research collaborations are formed globally. This condition underscores the need for a study that offers a more comprehensive overview of the topic. Therefore, this study is expected to provide both theoretical and practical contributions. Theoretically, it offers a scientific map that enriches the understanding of learning trajectory research developments. Practically, it provides insights for educators and future researchers in designing effective learning pathways that are aligned with students' cognitive growth.

Although learning trajectories have been widely discussed in mathematics education, few studies have systematically mapped their evolution, thematic orientations, and global collaboration networks using bibliometric approaches. As a result, the scholarly landscape on learning trajectories remains fragmented, limiting educators' and researchers' ability to obtain a comprehensive picture of its developmental direction. To address this gap, the present study integrates a Systematic Literature Review (SLR) with bibliometric analysis. This approach has rarely been combined in prior studies to produce a holistic, structured, and data-driven visualization of the research landscape in learning trajectory studies. Therefore, the objectives of this study are to: (1) analyze the development of learning trajectory research in mathematics education; (2) identify prevailing research trends and themes; (3) map conceptual relationships through bibliometric analysis; and (4) formulate recommendations for future research directions to enhance the implementation of learning trajectories in mathematics learning.

2. METHOD

2.1 Research Design

This study employed a *Systematic Literature Review* (SLR) to comprehensively examine the development of learning trajectory research in mathematics education through a structured process of identifying, selecting, and synthesizing relevant scientific publications. In addition, the review was enriched with a bibliometric analysis using VOSviewer version 1.6.20, which enabled the objective visualization of relationships among articles, authors, keywords, and citation patterns. The combination of SLR and bibliometric techniques generated two primary outcomes: (1) a narrative synthesis addressing the central focus of the study, and (2) a data-driven scientific map that illustrates the research landscape, thematic trends, and the progression of learning trajectory studies over the past decade. The literature search was conducted through the Scopus database, with a focus on publications from 2016 to 2025 to ensure relevance to current research developments.

2.2 Data Collection

The research data consisted of bibliographic metadata from Scopus-indexed journal articles containing the keyword *"learning trajectory."* The search process yielded 1,957 articles published between 2016 and 2025. All metadata were exported in CSV format, including article titles, authors, affiliations, publication years, citation counts, abstracts, and keywords. A *data cleaning* procedure was then performed, removing duplicate entries and normalizing variations in author names to ensure the final dataset was clean, accurate, and ready for analysis.

2.3 Screening and Selection

Article screening was conducted using the following inclusion criteria: (1) written in English, (2) focused on mathematics education, and (3) explicitly addressed learning trajectories. The screening process was conducted in several stages, beginning with an examination of the title, abstract, and keywords, followed by a complete content review to verify relevance. Articles that did not meet these criteria, such as those outside the context of mathematics education or not aligned with the research focus, were excluded from the analysis. After the whole screening process, 65 articles were deemed eligible for further investigation. The final dataset was processed using Microsoft Excel before being analyzed through bibliometric mapping.

2.4 Bibliometric Analysis

Bibliometric analysis was conducted using VOSviewer version 1.6.20 to identify conceptual linkages through keyword co-occurrence, author collaboration patterns (*co-authorship*), and citation networks. A minimum threshold of five keyword co-occurrences was applied to ensure that the thematic clusters generated were valid and reliable. The bibliometric results were visualized through three main outputs: *network visualization, overlay visualization,* and *density visualization,* each providing a comprehensive depiction

of conceptual structures, thematic trends, and the global research landscape on learning trajectories.

2.5 Data Interpretation

The bibliometric findings were then interpreted qualitatively to reveal dominant themes, conceptual linkages, emerging research topics, and underexplored areas within the field. This interpretive process allowed the study to objectively identify existing research gaps and propose potential directions for future inquiry. The interpreted results were subsequently integrated into the discussion section to reinforce the conclusions and support the formulation of research recommendations.

3. RESULTS AND DISCUSSION

3.1 Result

Article searching was conducted using Scopus as the primary database, as it provides a broad and credible source of scientific publications. The retrieved data were then analyzed using VOSviewer, which functions to visualize citation networks, inter-article relationships, and other bibliometric analyses, thereby facilitating a comprehensive identification of research trends. The search was performed using the keyword *"learning trajectory"* within the publication range of 2016–2025, yielding a total of 1,957 metadata articles. All metadata were exported in RIS format and subsequently analyzed using VOSviewer to map article interconnections, keyword distribution, and relevant research trends. The number of articles obtained over the last ten years was visualized in graphical form, as illustrated in Figure 1.

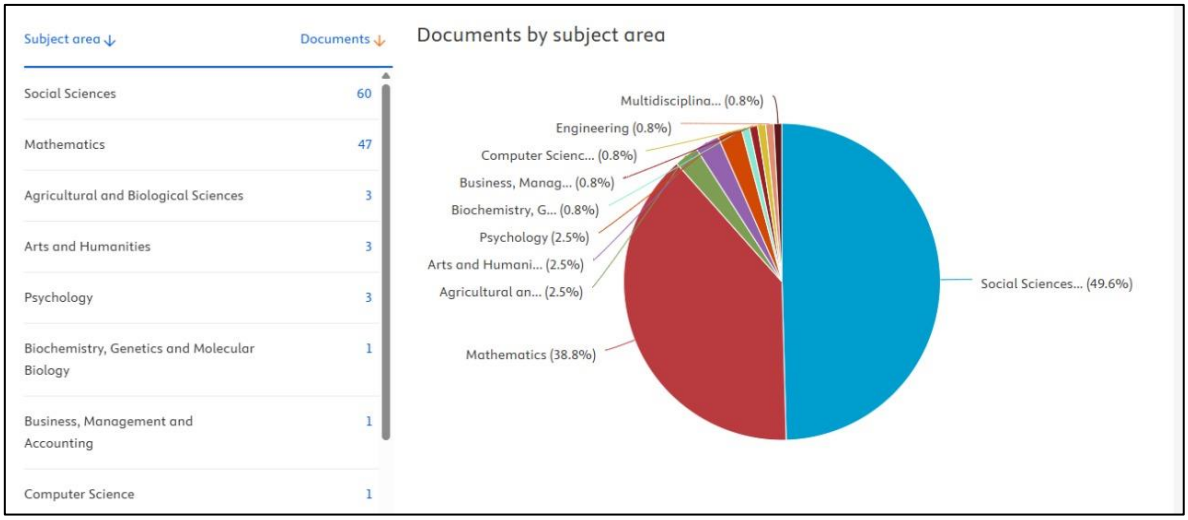

Figure 1. Distribution of Publications by Field of Study (2026-2025)

As shown in Figure 1, the distribution of articles by field of study indicates that research on learning trajectories is predominantly conducted in the Social Sciences, with 60 documents (49.6%), and Mathematics, with 47 documents (38.8%). Other fields, such as Agriculture and Biology, Arts and Humanities, and Psychology, each contributed three documents (2.5%), while the smallest contributions came from Biochemistry, Business and

Management, Computer Science, Engineering, and Multidisciplinary studies, with only 1 document each (0.8%). The distribution of learning trajectory publications from 2016 to 2025 is presented in Figure 2.

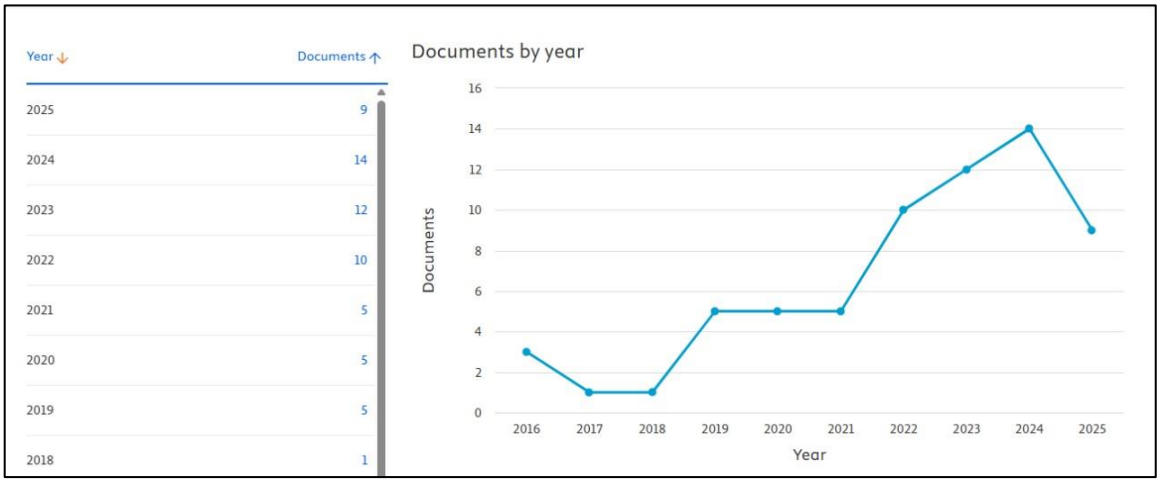

Figure 2. Distribution of Learning Trajectory Publications in 2016–2025

As shown in Figure 2, the distribution of articles by year of publication shows a clear upward trend over the past decade. In 2016, only three articles were recorded, followed by a decline to just one article in both 2017 and 2018. Subsequently, during the 2019–2021 period, the number of publications stabilized at approximately five articles per year. However, beginning in 2022, there was a sharp increase, with ten publications recorded, followed by twelve articles in 2023, and peaking at fourteen articles in 2024. Meanwhile, the year 2025 has so far recorded nine publications, and this number is expected to continue growing as the year progresses. This pattern suggests that scholarly interest in learning trajectory research has continued to rise, particularly after 2021, indicating that the topic has become increasingly relevant and has garnered broader attention in academic discourse. The distribution of learning trajectory publications by country from 2016 to 2025 is presented in Figure 3.

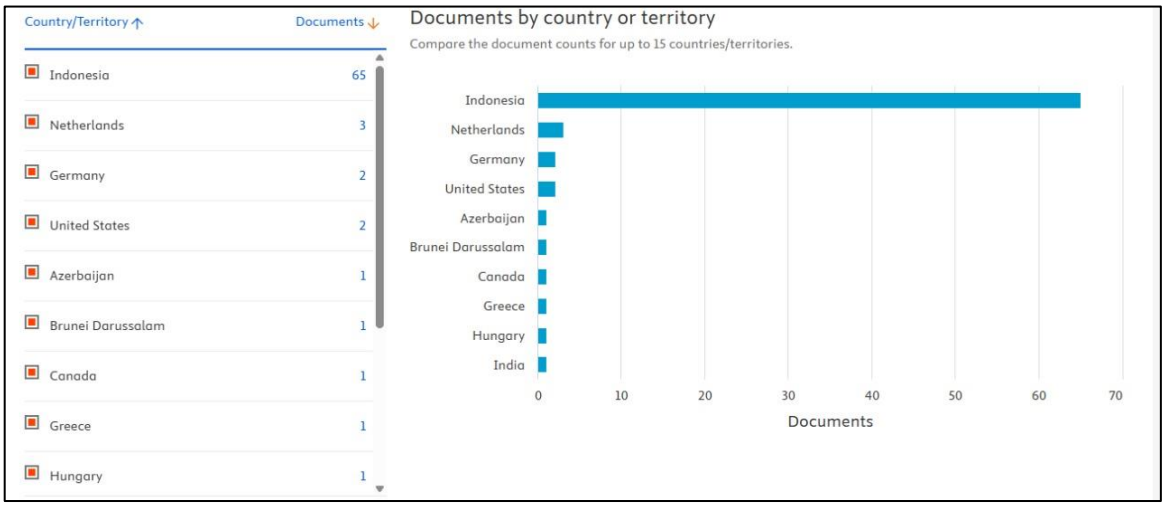

Figure 3. Distribution of Publications by Country in 2016–2025

As shown in Figure 3, Indonesia clearly dominates the landscape of learning trajectory research compared to other countries. This pattern indicates that the discourse remains nationally concentrated rather than globally distributed. The trend also reflects the strong influence of PMRI and design-based research traditions within Indonesian mathematics education. A more detailed breakdown of publication frequencies is presented in Table 1.

Table 1. Top Countries Publishing Learning Trajectory Studies (2016–2025)

No	Country	Number of Articles
1.	Indonesia	65
2.	Netherlands	3
3.	Germany	2
4.	United States	2
5.	Azerbaijan	1
6.	Brunei Darussalam	1
7.	Canada	1
8.	Crece	1
9.	Hungary	1
10.	India	1

As shown in Table 1, Indonesia's publication volume far surpasses that of other countries, reinforcing its position as the central hub for learning trajectory research. The limited and dispersed contributions from other countries suggest that the discourse has not yet developed as a global mainstream topic. These findings highlight the need for broader international collaboration to diversify research contexts and perspectives. The following section examines the distribution of publication patterns across journals. The distribution of learning trajectory publications, categorized by journal, is presented in Figure 4.

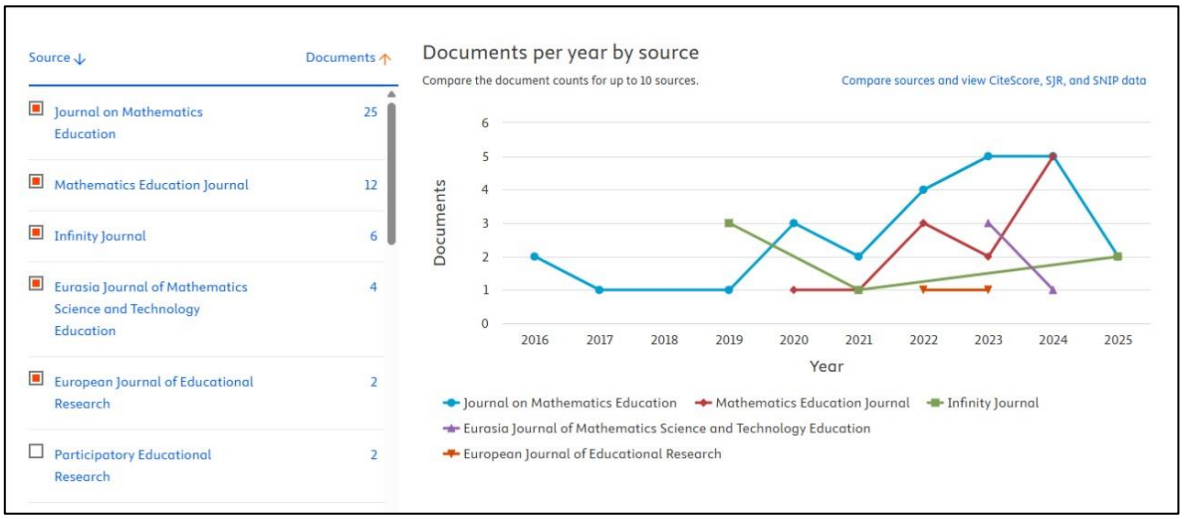

Figure 4. Distribution of Learning Trajectory Publications by Journal in 2016–2025

As shown in Figure 4, publications on learning trajectories are concentrated in several core journals, particularly those in the field of mathematics education. The *Journal on Mathematics Education* appears as the primary outlet, followed by a smaller number of

supporting journals. This pattern suggests that the development of learning trajectory research is shaped by a relatively specific academic community, while still maintaining connections with broader international publication networks. To provide a more straightforward overview of the publication frequency across these outlets, the detailed distribution is presented in Table 2.

Table 2. Top Journals Publishing Learning Trajectory Studies (2016–2025)

No	Journal Name	Number of Articles
1.	Journal on Mathematics Education	25
2.	Mathematics Education Journal	12
3.	Infinity Journal	6
4.	Eurasia Journal of Mathematics, Science and Technology Education	4
5.	European Journal of Educational Research	2
6.	Participatory Educational Research	2

As shown in Table 2, the publication pattern shows that learning trajectory studies are primarily disseminated through journals that emphasize instructional design, classroom experimentation, and culturally grounded learning approaches. The dominance of national journals reflects the strong research tradition in Indonesia, particularly within the mathematics education community. Meanwhile, although fewer in number, contributions from reputable international journals suggest that the topic is beginning to gain wider recognition. These findings suggest the need for broader international collaboration to expand research perspectives and strengthen the global visibility of learning trajectory studies. Beyond journal outlets, research activity can also be traced through institutional or author affiliations, providing insight into which institutions are most active in advancing the topic, as illustrated in Figure 5.

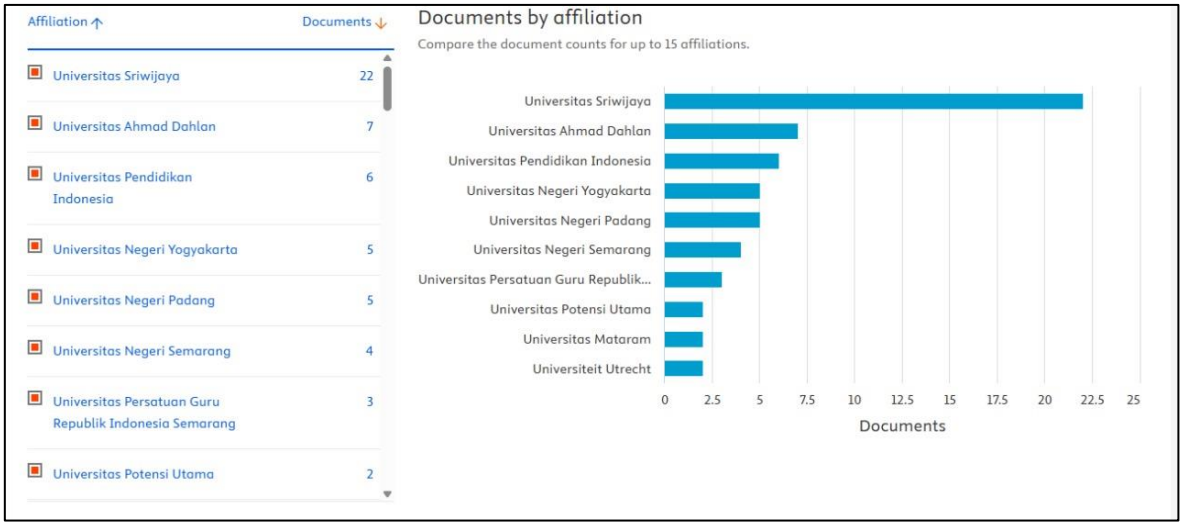

Figure 5. Distribution of Learning Trajectory Publications by Affiliation

As shown in Figure 5, the distribution of scientific publications indicates that Universitas Sriwijaya holds the top position, with a total of 22 articles. This number is significantly higher than other affiliations, indicating strong research productivity

supported by institutional commitment, adequate human resources, and well-established collaborative research networks. Following this, Universitas Ahmad Dahlan contributed seven articles, while Universitas Pendidikan Indonesia produced six articles. Additionally, Universitas Negeri Yogyakarta and Universitas Negeri Padang each published five articles, and Universitas Negeri Semarang contributed four articles.

Meanwhile, several other institutions, such as Universitas Persatuan Guru Republik Indonesia Semarang (3 articles), Universitas Potensi Utama (2 articles), as well as Universitas Mataram and Utrecht University, each recorded a smaller number of publications. Beyond institutional analysis, it is also important to examine the productivity of individual authors to identify key contributors who consistently influence the development of learning trajectory research. This information is illustrated in Figure 6.

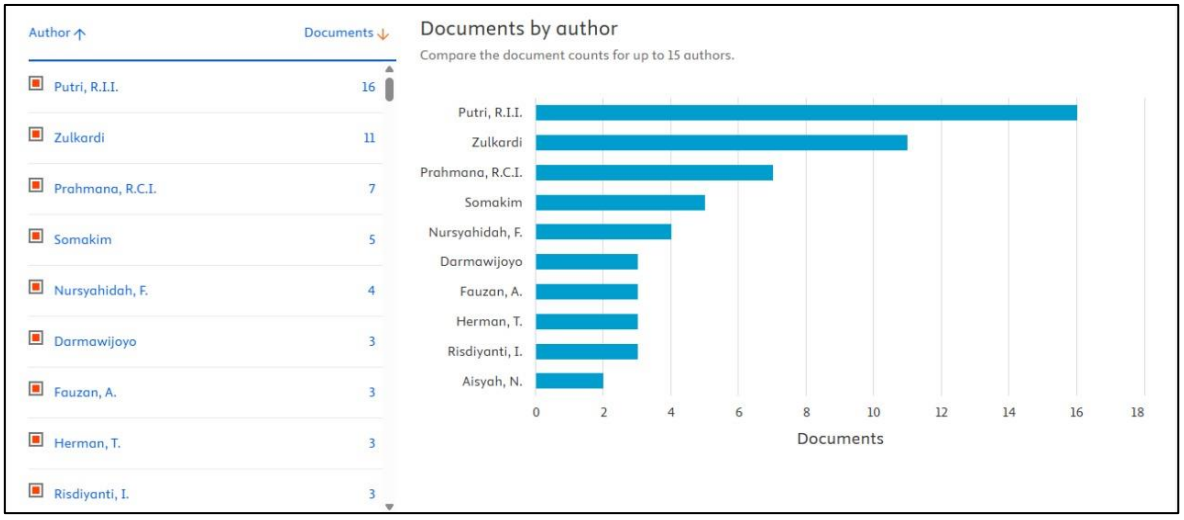

Figure 6. Distribution of Learning Trajectory Publications by Authors

As shown in Figure 6, the productivity of scientific publications can be mapped based on contributing authors. The data indicate that Putri, R.I.I. ranks first with a total of 16 articles, followed by Zulkardi with 11 articles and Prahmana, R.C.I., with seven articles. These three authors can be categorized as the most productive and influential contributors in the field of learning trajectory research. In addition to publication counts, author impact was also considered, as reflected in their strong co-authorship networks and consistent collaboration patterns. A co-authorship visualization using VOSviewer highlights tightly connected clusters, suggesting active collaborative ecosystems that drive research development in this field.

Furthermore, Somakim (5 publications) and Nursyahidah, F. (4 publications) form a group of authors with moderate productivity, while several others, such as Darwisyojo, A., Fauzan, T., Herman, I., Risdiyanti, and Aisyah, N., each contributed three publications. Although smaller in number, these authors still demonstrate meaningful scholarly contributions. Collectively, these findings demonstrate that the advancement of learning trajectory research is primarily driven by a core group of active scholars who continually influence the growth of publications and academic discourse in mathematics education.

Table 3. The Top 5 most cited articles in this field are presented

No	*Author*	*Title*	*Year*	*Source Title*	*Cite by*
1.	Prahmana & Kusumah [19]	*The hypothetical learning trajectory on research in mathematics education using research-based learning*	2016	Pedagogika	40
2.	Risdiyanti & Prahmana [20]	*The learning trajectory of number pattern learning using barathayudha war stories and uno stacko*	2020	Journal on Mathematics Education	29
3.	H. Hendriana, R. C. I. Prahmana, and W. Hidayat [21]	The innovation of learning trajectory on multiplication operations for rural area students in indonesia	2019	Journal on Mathematics Education	27
4.	A. Wijaya, E. Elmaini, and M. Doorman [22]	*A learning trajectory for probability: a case of game-based learning*	2021	Journal on Mathematics Education	19
5.	Risdiyanti & Prahmana [23]	*Designing the learning trajectory of a set through the indonesian shadow puppets and the Mahabharata stories*	2021	Infinity Journal	17

As shown in Table 3, the five most-cited articles serve as the primary references in learning trajectory research. The article with the highest citation count is *"The Hypothetical Learning Trajectory on Research in Mathematics Education Using Research-Based Learning" [19], published in Pedagogika, which has garnered* 40 citations. This work serves as a foundational reference that introduces and strengthens the concept of Hypothetical Learning Trajectory (HLT) within mathematics education, particularly through a research-based learning approach. The second most-cited article is *"The Learning Trajectory of Number Pattern Learning Using Barathayudha War Stories and Uno Stacko" [20],* with 29 citations. This study demonstrates how cultural narratives (Barathayudha stories) and educational games (Uno Stacko) can support students' development of number pattern concepts, emphasizing the integration of ethnomathematics and game-based learning. *The learning trajectory of number pattern learning using Barathayudha war stories and Uno Stacko* has obtained 29 citations. This article affirms the contribution of cultural contexts (Barathayudha stories) and games (Uno Stacko) in supporting the learning trajectory of number patterns, and shows the integration between ethnomathematics and game-based learning.

The third article, *"The Innovation of Learning Trajectory on Multiplication Operations for Rural Area Students in Indonesia" [21], has 27 citations and highlights innovative designs of learning trajectories for multiplication, particularly for students in rural areas, thereby* promoting equitable access to mathematics learning. In fourth place, *"A Learning Trajectory for Probability: A Case of Game-Based Learning" [22], with 19 citations,* presents a shift in research direction by applying game-based learning to support students' understanding of probability. Lastly, the article titled *"Designing a Learning*

Trajectory of Set Through Indonesian Shadow Puppets and Mahabharata Stories" [23], published in Infinity Journal with 17 citations, integrates local cultural heritage, such as wayang kulit and Mahabharata stories, into the design of a learning trajectory for set concepts. Collectively, these five studies illustrate that research on learning trajectories has evolved not only in methodological strength but also in contextual richness. The trend highlights the incorporation of cultural contexts, innovative learning tools, and social relevance, confirming that learning trajectories are a flexible and adaptive framework that continues to grow in response to diverse educational needs.

Following the identification of the most-cited articles, the analysis was extended using network visualization. The visualization maps the interconnectedness of keywords based on co-occurrence frequency, producing cluster structures that represent dominant research orientations in learning trajectory studies. The resulting network reinforces the finding that learning trajectory research primarily focuses on mathematics education and is strongly associated with methodological approaches, classroom teaching experiments, the integration of ethnomathematics, and the use of digital technology. These interconnected keyword clusters reveal how the learning trajectory topic has developed across multiple research pathways. The network visualization thus functions as a foundation for understanding how major themes evolve and interrelate across the literature, offering a clearer picture of the knowledge structure within this research domain.

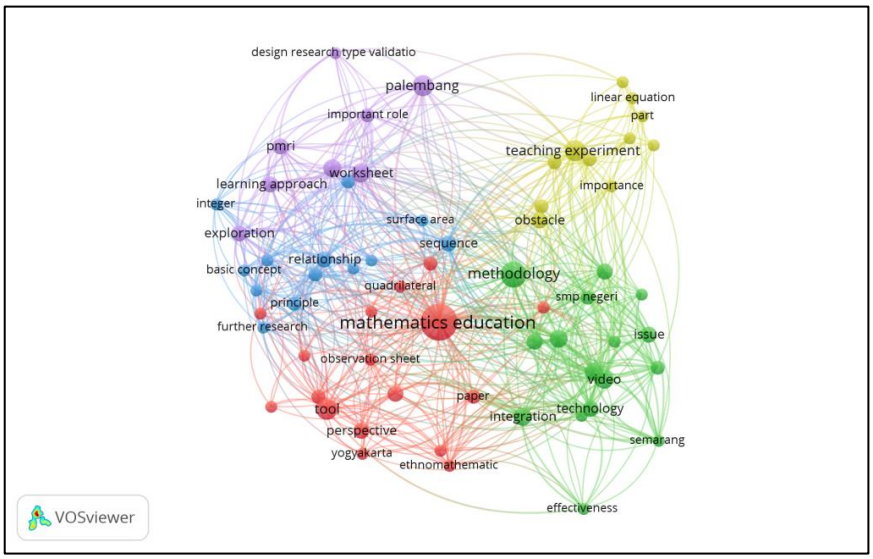

Figure 7. Network Visualization

As shown in Figure 7, the network visualization illustrates the mapping of interrelated keywords within learning trajectory research in mathematics education. The size of each node represents the frequency of keyword occurrences, while the thickness of the connecting lines indicates the strength of co-occurrence relationships among the terms. The keyword *"mathematics education"* appears as the central node with the largest size, signifying its position as the primary focus within this body of literature. Other keywords occupying central positions include *"methodology," "teaching experiment," "ethnomathematic,"* and *"technology."* This indicates that learning trajectory research not

only stems from the theoretical foundation of mathematics education but has also expanded toward methodological approaches, classroom teaching experiments, cultural integration, and the utilization of digital technology in learning.

Furthermore, the color-based clusters in the visualization reveal several research orientations that differ yet complement one another. The purple-blue cluster emphasizes concepts such as design research, PMRI (Realistic Mathematics Education in Indonesia), and worksheet development, reflecting a research focus on instructional design and realistic learning approaches. The red cluster highlights *ethnomathematical*, *tool*, and *perspective*, underscoring the cultural dimension and instrument development within learning trajectories. Meanwhile, the green-yellow cluster demonstrates strong associations with *technology*, *integration*, *video*, and *effectiveness*, representing emerging trends that prioritize digital media integration and evaluation of learning effectiveness in mathematics instruction. Subsequently, an overlay visualization is employed to incorporate a temporal dimension by displaying the distribution of keywords according to their year of emergence. This visualization offers insights into the evolution and shifting focus of learning trajectory research, from earlier studies to the most recent publications, as illustrated in Figure 8.

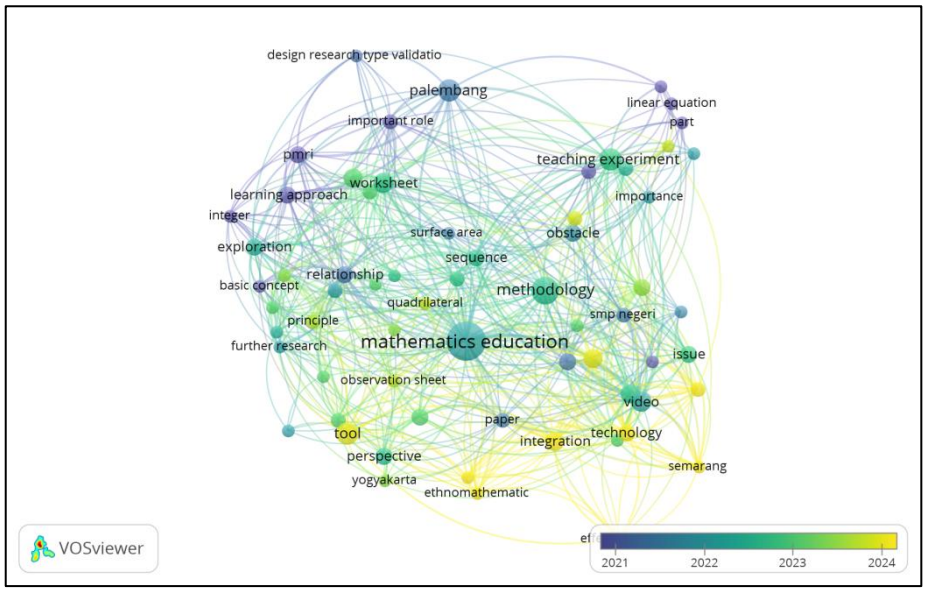

Figure *8.* Overlay Visualization

As shown in Figure 8, the bibliometric visualization generated using VOSviewer illustrates the co-occurrence relationships of keywords in learning trajectory research within mathematics education. Larger nodes, such as *"mathematics education"* and *"methodology,"* indicate keywords with high frequencies, suggesting that the core focus of learning trajectory studies is rooted in methodological development for mathematics learning. In addition, keywords such as *"teaching experiment," "worksheet," "tool," "integration,"* and *"technology"* also show strong connectivity with the central terms, reflecting their relevance within the research landscape.

The color gradation in Figure 8 represents the temporal dynamics of keyword emergence over time. Darker-colored keywords such as *"design research," "PMRI,"* and *"basic concept"* dominated earlier periods (around 2021). Conversely, brighter-colored

keywords such as *"ethnomathematic," "integration," "technology,"* and *"video"* have appeared more recently (2023–2024), signaling a shift in research focus toward technology integration and culturally oriented learning approaches. Moreover, the linkage of keywords such as *"ethnomathematic," "Semarang,"* and *"Yogyakarta"* indicates that Indonesian researchers have made notable contributions by incorporating local cultural contexts into learning trajectory designs. Following the overlay visualization, the density visualization highlights the intensity of keyword occurrences. This visualization helps identify dominant research topics more clearly, while simultaneously revealing areas that remain underexplored, as shown in Figure 9.

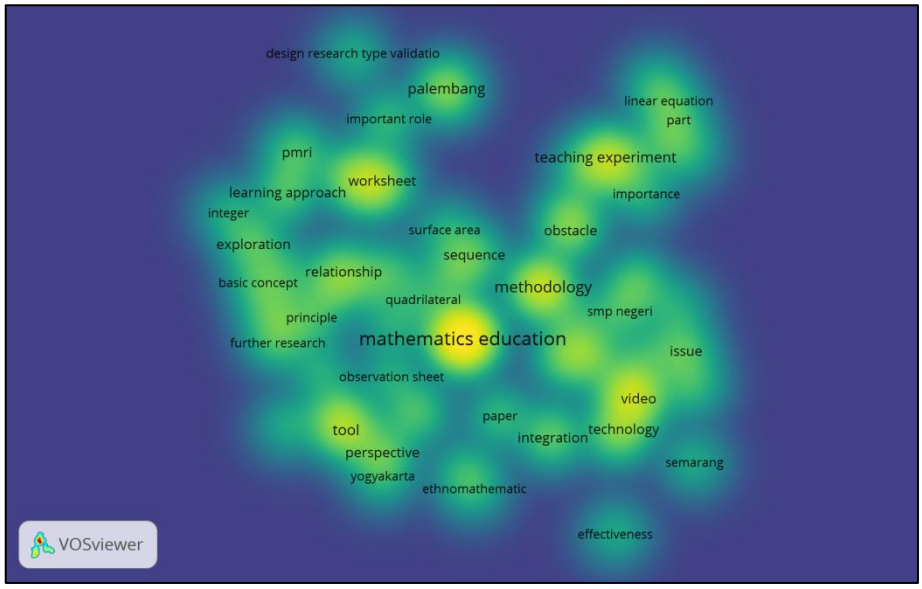

Figure 9. Density Visualization

As shown in Figure 9, the density visualization illustrates the intensity of keyword occurrences in learning trajectory research within the field of mathematics education. Brighter colors (yellow) indicate keywords with high frequencies, whereas darker shades (green to blue) represent keywords with lower frequencies. The keyword *"mathematics education"* appears as the most dominant term, indicating its central position in learning trajectory studies. This confirms that mathematics education is the primary domain in which learning trajectories have been extensively examined.

In addition, keywords such as *"methodology," "worksheet," "teaching experiment," "tool," "technology,"* and *"video"* also appear prominently, reflecting research trends that emphasize methodological development, instructional tool design, classroom experimentation, and the integration of technology. Meanwhile, keywords with medium to low intensity, such as *"ethnomathematic," "integration," "exploration,"* and *"effectiveness,"* represent relevant research areas that remain underexplored. These findings suggest significant opportunities for future investigations, particularly those that link learning trajectories with local cultural contexts and evaluate instructional effectiveness.

3.2 Discussion

The bibliometric analysis reveals three dominant orientations in Learning Trajectory (LT) research, namely: (1) methodological strengthening, (2) cultural contextualization through ethnomathematics, and (3) technology–enhanced learning trajectories. This finding demonstrates that LT has evolved not only as a classroom strategy but also as a conceptual framework that aligns with the demands of 21st-century learning, particularly the *4C skills (critical thinking, creativity, collaboration, and communication)*. The bibliometric analysis also shows that research on LT is predominantly developed within the field of mathematics education. This suggests that LT is perceived as a relevant conceptual framework for mapping students' thinking processes as they progressively develop an understanding of mathematical concepts. Theoretically, this result aligns with the fundamental components of LT, which emphasize the interrelationship between learning objectives, instructional activities, and hypotheses about students' cognitive development [18]. Research in [24] confirms that LT supports students in building geometric understanding step by step until they reach conceptual generalization. Similarly, studies in [13], [25] demonstrate that LT facilitates students' cognitive transitions from concrete representations to abstract models, resulting in meaningful conceptual understanding rather than procedural memorization.

From a temporal perspective, the increasing publication trend after 2021 shows that LT has become more relevant in the post-pandemic era. This shift reflects the urgent need for systematic and flexible learning pathways to address learning loss and support continuity in conceptual development, particularly in student-centered learning environments. This is consistent with [5], [12], which highlight that post-pandemic learning demands explicit learning trajectories to maintain students' cognitive progress. Therefore, the growth of LT publications represents a concrete response to global changes in instructional paradigms rather than a mere academic trend.

The distribution of publications across countries also shows that Indonesia has become the central hub of LT research, influenced by the strong tradition of Realistic Mathematics Education (RME) and the design research approach. Study [17] shows that constructing a Hypothetical Learning Trajectory (HLT) significantly enhances students' mathematical reasoning through well-structured stages. Similarly, [11] demonstrates that integrating local cultural contexts within LT makes learning more meaningful and relevant to students' lived experiences. Thus, the dominance of Indonesian publications confirms that LT has emerged as a methodological identity within the Indonesian mathematics education research community.

In terms of the publication ecosystem, the concentration of LT studies in mathematics education journals indicates the formation of a strong research cluster supported by recurring authors and institutions. While this condition strengthens theoretical continuity, it also signals a limited diversification of perspectives, leaving international collaboration as a major opportunity for future expansion. Keyword analysis reveals three major thematic directions in LT development: (1) methodological strengthening through teaching experiments, (2) cultural integration through ethnomathematics, and (3) the instructional use of digital technology.

Cultural integration in LT has been widely explored, as shown in [11], [16], which emphasize that cultural contexts enhance students' cognitive engagement. Meanwhile, technology-assisted LT is emerging as a growing trend. The integration of digital tools and learning analytics shows potential for developing adaptive and real-time LT models, although current empirical evidence remains limited. However, the density visualization also indicates a substantial research gap. Studies [17], [24]–[26] consistently report that LT research is still predominantly focused on elementary and secondary school contexts. Research on early childhood education, higher education, cross-country comparisons, and longitudinal studies remains scarce. Therefore, future LT research should expand to include learning analytics, AI-assisted LT, and cross-cultural exploration, in order to provide broader theoretical contributions and greater global relevance.

This study is limited to Scopus-indexed publications written in English, which may exclude relevant regional scholarship and non-English studies that could provide additional perspectives. Despite this limitation, the findings make a significant contribution to the current understanding of LT research trends. These insights inform policymakers, curriculum developers, and educators on how LT-based research can guide the design of inclusive, culturally responsive, and future-oriented curricula that align with 21st-century learning competencies and global education goals.

4. CONCLUSION

This study shows a significant growth of Learning Trajectory (LT) research in mathematics education, especially after 2021, with Indonesia as the most dominant contributor; bibliometric results confirm that LT studies are primarily linked to mathematics education, teaching methodologies, ethnomathematics, and technology-supported instruction, indicating a shift from conceptual themes toward more culture-based and technology-oriented innovations. Theoretically, this strengthens LT as an adaptive framework that connects learning theory, cultural context, and digital innovation. Practically, it highlights the need for wider cross-institutional collaboration and LT-based curriculum designs that are inclusive and student-centered. Future research should expand to underexplored contexts, including early childhood, higher education, cross-cultural comparisons, longitudinal studies, and the use of AI-powered learning analytics to enhance global relevance and support more personalized and responsive LT implementations in the 21st-century learning landscape.

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