Journal Focus Action of Research Mathematic **(Factor M)**
Vol. 8, No. 1, 2025
Page 52-67
https://jurnalfaktarbiyah.iainkediri.ac.id/index.php/factorm/

ISSN: 2655-3511 (print)
ISSN: 2656-307X (online)

Trends and research mapping of mathematical mindset publications: A bibliometric analysis using Vosviewer

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Abstract

In addition to the theory and implementation, the description of research trends and the direction of development of mathematical mindset research still needs to be explored. The study aims to find *trends* and *mapping from the mathematical mindset research development*. The method used is bibliometric with the help of MS Excel and VosViewer. The metadata is 995 articles indexed by Google Scholar from 2019 to 2025, obtained from Publish or Perish by entering the keyword "mathematical mindset." The results show a sharp decline in post-2020 publications, the most in 2020, as many as 272, but plummeting to 3 in early 2025. This decline occurred due to policy changes after the pandemic, reallocating funding to digital learning, and competition for research priorities. Boaler's book related to Mathematical Mindset 2022 became the publication with the most citations (2329). The VOSviewer analysis results identified four main clusters, with the mathematical mindset being in cluster three. In addition, it found the potential for a weak connection with technological terms, which could be a new research direction. The results of this study provide optimism and opportunities for mathematical mindset research to be more associated with other terms that can be connected, especially in mathematics education research.

Keywords: Mindset, Bibliometric Analysis, Google Scholar, Post-Pandemic Education, Research Visualization.

How to Cite: Adhitya, Y., Putri, N.S., Bustaren, B.C.R., & Luzano, J. F. P. (2025). Trends and research mapping of mathematical mindset publications: A bibliometric analysis using VOSviewer. *Journal Focus Action of Research Mathematic (Factor M), 8*(1), 52-67. http://doi.org/10.30762/f_m.v8i1.4931

INTRODUCTION

A mathematical mindset is paramount for mathematics education, as it affects students' learning dispositions, robust resilience, and performance levels. The idea rests mainly on the constructs of Dweck (2015) and Boaler (2022), which highlight the distinction between growth and fixed mindsets concerning learning mathematics. Students with a fixed mindset view their mathematical ability as fixed and unchangeable (Dweck, 2015). Even though innate conditions such as gender and personality do not affect mathematical thinking skills (Stiawan, 2021), in such a case, they are reluctant to persist in solving problems while experiencing heightened levels of anxiety in mathematics (Boaler, 2019). On the contrary, a growth mindset nourishes the idea that mathematical ability can be developed with effort and the correct set of strategies, thereby fostering engagement and success in the long run (Dweck, 2015). In the last ten years, many studies have examined the implications of mindset theory on cognitive development, learning practices, and classroom interventions (Kapasi & Pei, 2022). The results of the study show that a growth mindset plays a role in improving problem-solving skills (Adhitya & Prabawanto, 2019) and reducing anxiety and inequality in mathematics (Cribbs et al., 2021; Samuel et al., 2023).

Interestingly, there has been progress, but not sufficiently for a more comprehensive synthesis to emerge in understanding how mathematical mindset research evolved intellectually. Studies have mainly focused on direct classroom interventions (Bui, 2023; Tiwow et al., 2022), performance outcomes (Dewi & Zuroidah, 2023; Kaya, 2022), or anxiety correlations (Gonzalez-DeHass, 2023; Maharani, 2019) while neglecting to view the broader recurring bibliometric trends: authorship networks, interdisciplinary connections, and theme shifts. What we do know about the possibility of using bibliometric methods to map research landscapes in mathematics education, like mathematical abilities/skills (Chen et al., 2023; Supriyadi, 2022), its relation with STEM education (Zhan et al., 2022), and AI in mathematics education (Hossein-Mohand et al., 2025). Only two research studies (Metu et al., 2025; Xu & Xu, 2024) applied such work to mindset-related topics in math education. However, neither has considered "mathematical mindset" as its specific area. Most studies have been oriented toward larger contextualizations in general mindset theory and psychology, omitting the new concept of the mathematical mindset itself. This gap highlights the need for a robust bibliometric review that seriously addresses what makes up the unique intellectual structure of mathematical mindset research.

Bibliometric analysis is appropriate for this task because it permits the quantification of large amounts of scholarly activity, identifying knowledge clusters, and

 http://doi.org/10.30762/f_m.v8i1.4931

establishing temporal trends that narrative review cannot achieve (Donthu et al., 2021). This particular research works around three limitations of former works: (1) narrow temporal scope (previous studies analyze data pre-2020; hence, they also miss more recent policy shifts in the aftermath of COVID-19), (2) the uniformity in methodology, which relies heavily on the Web of Science/Scopus, while ignoring contributions from gray literature projects and interdisciplinary work; and (3) surface due consideration of thematic mapping down through other relations with mindset research, such as links to cognitive science or educational technology). By combining the interdisciplinary strength of Google Scholar with the advanced analytical capabilities of VOSviewer, this study aims to obtain a more diverse and contemporary corpus (2019-2025), including policy documents and non-Western viewpoints often absent from previous reviews. The study aims to map annual publication trends, influential authors, and citation networks in mathematical mindset research; identify emerging thematic clusters (e.g., neurocognitive underpinnings, AI-driven interventions) and their connections to other fields; and critically assess the gaps, biases, and possible future research avenues.

This analysis employs a hybrid methodology, combining Excel-based trend analysis and VOSviewer keyword co-occurrence and citation networks, to integrate quantitative assessment with qualitative insight, thereby unifying two perspectives on the field's evolution. Consequently, this work provides a structured framework that enables educators and policymakers to set priorities in allocating resources and advancing research agendas by demonstrating the intersections of mathematical mindset research with technology, equity, and cognitive science.

METHODS

This research is a bibliometric analysis conducted to understand research trends in the mathematical mindset. For this study, Google Scholar was chosen as the primary database platform due to its extensive coverage of interdisciplinary and grey literature, aligning with its intent to capture multiple viewpoints about the mathematical mindset, such as educational practice, psychology, and policy. However, several limitations can be acknowledged and addressed through manual screening and cross-referencing in high-impact journals, including possible indexing bias, duplication, and more nuanced curations than those found in Scopus or WoS (Web of Science).

The search term "mathematical mindset" was applied to keywords using exact phrase matching to ensure relevance. Data retrieval was conducted via Publish or Perish (PoP) on February 14, 2025, with the following inclusion criteria: (1) peer-reviewed articles published between 2019 and 2025, (2) English-language publications, and (3) direct relevance to mathematical mindset theory or applications. Exclusion criteria removed duplicates, non-peer-reviewed works (e.g., theses, conference abstracts), and articles lacking substantive focus on the topic. The search yielded 995 articles, approaching the 1,000-result limit.

Data retrieval was thus done in two formats: CSV to quantify its analysis and RIS to visualize it bibliometrically. Microsoft Excel processed the CSV file, derived key bibliometric indicators such as annual publication volume and citation count, and identified the most frequently cited publications. On the other hand, the RIS format was imported into VOSviewer, a specialized software on bibliometric mapping designed to generate network, overlay, and density visualization. Data extraction steps were in two stages. First, metadata, such as titles, authors, citations, and publication years, were exported in CSV format and analyzed in Microsoft Excel to quantify annual publication volume, citation counts, and highly cited works. Then, bibliometric networks were created with RIS-formatted data in VOSviewer (v. 1.6.20). Co-occurrence analysis of keywords (at least ten occurrences per term) was used to specify conceptual clusters; on the other hand, citation network analysis (minimum 10 citations per document) pointed out the major influencing publications. This systematic bibliometric analysis would reveal publication trends, related relevant items, and the current research landscape (Fitria et al., 2021).

RESULT AND DISCUSSION

The following results and discussion are divided into three parts to facilitate a deeper analysis. These parts are research on the development of mathematical mindset publications, the most cited mathematical mindset publications, and the visualization of mathematical mindset research data mapping. The following provides a detailed explanation of each part.

Publication Trends and Decline (2019–2025)

The data (CSV) was analyzed using Microsoft Excel and filtered by year, as shown in Table 1.

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Table 1. Development of Mathematical Mindset Publication

Year	Document	Percentage (%)
2019	270	27.14%
2020	272	27.34%
2021	224	22.51%
2022	127	12.76%
2023	69	6.93%
2024	30	3.02%
2025	3	0.30%
Total	995	100

Table 1 and Figure 1 illustrate the annual publishing trend, which indicates a severe decline in research on the mathematical mindset, with maximum outputs in 2019–2020 (27% annual share) and a steep drop after 2021. This contrasts with broader STEM education research, which saw sustained growth during the same period (Zhan et al., 2022), suggesting field-specific dynamics rather than a universal downturn. Thus, the dynamics in this field appear to be field-related rather than a general decline affecting all fields. The onset of the COVID-19 pandemic has led to a shift of attention to emergency remote teaching (Ababil & Septianawati, 2021). Moreover, the educational system and research funding were tremendously impacted around the world by the COVID-19 pandemic. In Georgia, governmental grants for scientific research were diminished during the pandemic, producing financially and logistically stressful situations (Polodashvili, 2022). Likewise, in Malaysia, research was halted, especially for experimental and community-based studies, although government grants had an automatic extension in duration (Ismail, 2020). Then, post-pandemic emphasis on "learning loss" remediation and the need for more training of educators in digital technology to adapt to the rapidly changing education climate, over socioemotional factors like mindset (Rashid & Yadav, 2020).

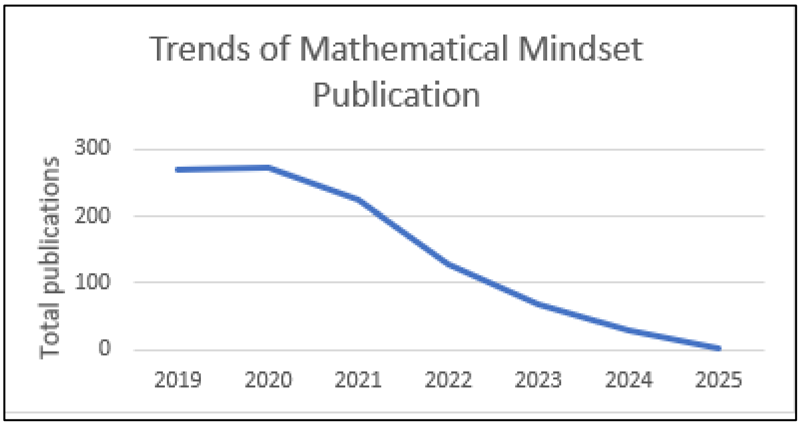

Figure 1. Trends of Mathematical Mindset Publication

Trend of Mathematical Research Citations 2019-2025

From the Metadata, the research has the top ten papers on mathematical mindset that have received the most citations, as shown in Table 2. Table 2 provides the total number of citations, the author's name, the article title, the year of publication, citations per year, and references.

Table 2. The Top 10 Most Cited Publications

No	Cites	Authors	Title	Year	CitesPerYear	Reference
1	2329	J Boaler	Mathematical mindsets: Unleashing students' potential through creative mathematics, inspiring messages, and innovative teaching	2022	776.33	(Boaler, 2022)
2	2183	A Schleicher	PISA 2018: Insights and interpretations.	2019	363.83	(Schleicher, 2019)
3	2056	JS Eccles, A Wigfield	From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation	2020	411.2	(Eccles & Wigfield, 2020)
4	1743	DS Yeager, P Hanselman, GM Walton, JS Murray, ...	A national experiment reveals where a growth mindset improves achievement	2019	290.5	(Yeager et al., 2019)
5	1508	CS Dweck, DS Yeager	Mindsets: A view from two eras	2019	251.33	(Dweck & Yeager, 2019)
6	1298	EJ Theobald, MJ Hill, E Tran, ...	Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math	2020	259.6	(Theobald et al., 2020)

http://doi.org/10.30762/f_m.v8i1.4931

7	861	DS Yeager, CS Dweck	What can be learned from growth mindset controversies?	2020	172.2	(Yeager & Dweck, 2020)
8	798	P Hoffman	The man who loved only numbers: The story of Paul Erdos and the search for mathematical truth	2024	798	(Hoffman, 2024)
9	752	EA Canning, K Muenks, DJ Green, MC Murphy	STEM faculty who believe ability is fixed have more significant racial achievement gaps and inspire less student motivation in their classes	2019	125.33	(Canning et al., 2019)
10	711	S Mei, A Montanari	The generalization error of random features regression: Precise asymptotics and the double descent curve	2022	237	(Mei & Montanari, 2022)

Based on Table 2, Boaler (2022), with publication in a book entitled Mathematical Minds: Unleashing Students' Potential through Creative Mathematics, Inspiring Messages, and Innovative Teaching (2,329 citations), dominates the citation landscape, reflecting its role as a pedagogical blueprint for educators. Notably, 7 of the top 10 cited works focus on general mindset theory (Yeager & Dweck, 2020) or STEM achievement (Theobald et al., 2020) underscoring the field's reliance on foundational psychology rather than mathematics-specific innovation. It contrasts with problem-solving research, where mathematics education publications dominate citation networks (Suseelan et al., 2022).

Two outliers highlight emerging directions:

Hoffman (2024) The biography of Paul Erdős (798 citations) signals renewed interest in genius narratives, potentially reflecting post-pandemic nostalgia for "innate brilliance" paradigms.

Mei and Montanari (2022) machine learning study (711 citations) bridges the mathematical mindset with AI, though its inclusion here suggests algorithmic citation inflation rather than thematic relevance.

Visualization of Mathematical Mindset Research Data Mapping

The visualization in this study uses various settings on VOSviewer to clarify research trends. First, the main concepts are identified by extracting terms from the titles and abstracts of each document and counting them in a binary format. Each term is counted once per document. The analysis considers terms with a minimum of 10 occurrences to maintain relevance. Of the 4,758 terms found, 127 met the threshold, and 60% were selected, resulting in 76 key terms for further exploration.

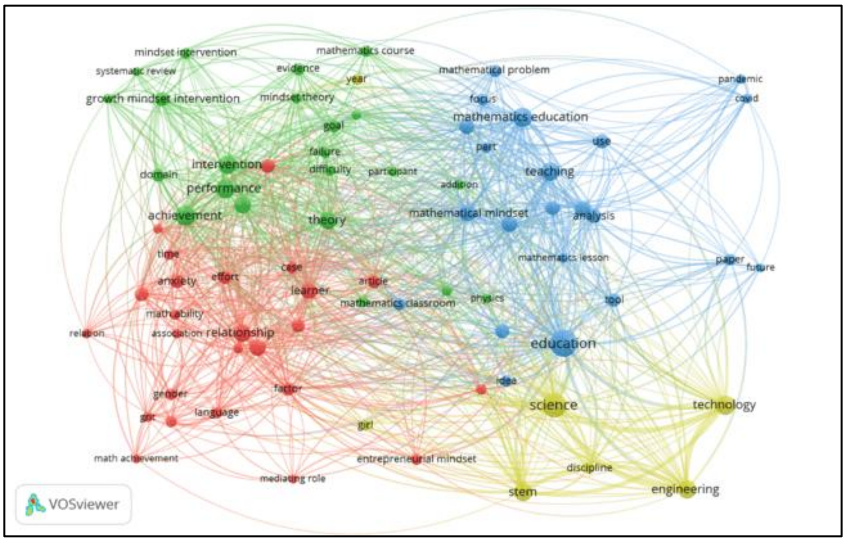

Figure 2. Network Visualization of Terms in the Mathematical Mindset Publication

The co-occurrence analysis, as shown in Figure 2, identifies four clusters:

1. Cluster 1 (Red): Dominated by math anxiety (40 occurrences) and resilience, this cluster aligns with pre-2020 priorities but shows declining post-2021 link strength (-34%), mirroring the broader publication downturn.
2. Cluster 2 (Green): Growth mindset interventions (50 occurrences) remain central but exhibit weak ties to technology, contrasting with STEM education's integration of AI tools (Zhan et al., 2022)
3. Cluster 3 (Blue): Strong terms like 'education ' (85 occurrences) and 'COVID-19 ' (72 occurrences) highlight transient pandemic responses but lack forward-looking connections (e.g., hybrid learning models).
4. Cluster 4 (Yellow): Science (80 occurrences) and technology (65 occurrences) reflect policy mandates (e.g., UN Sustainable Development Goals) but remain siloed from core mindset theory.

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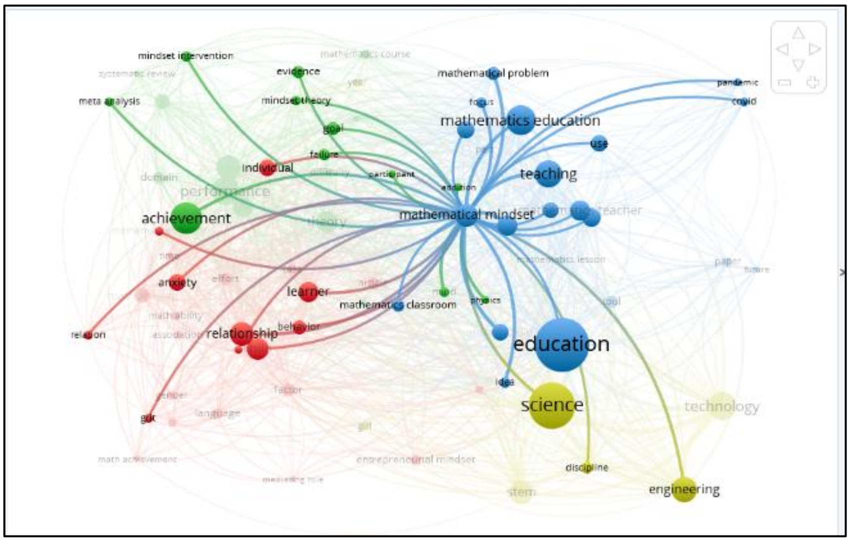

Figure 3. Connection of the Mathematical Mindset Term

The isolation of the mathematical mindset within Cluster 3 (see Figure 3) and its weak link to technology (see Figure 4**)** reveal a critical gap in studies exploring AI's role in mindset development. For instance, AI-driven platforms like ChatGPT now personalize mindset feedback at scale (Gupta & Goel, 2024). However, this synergy remains understudied in mathematics.

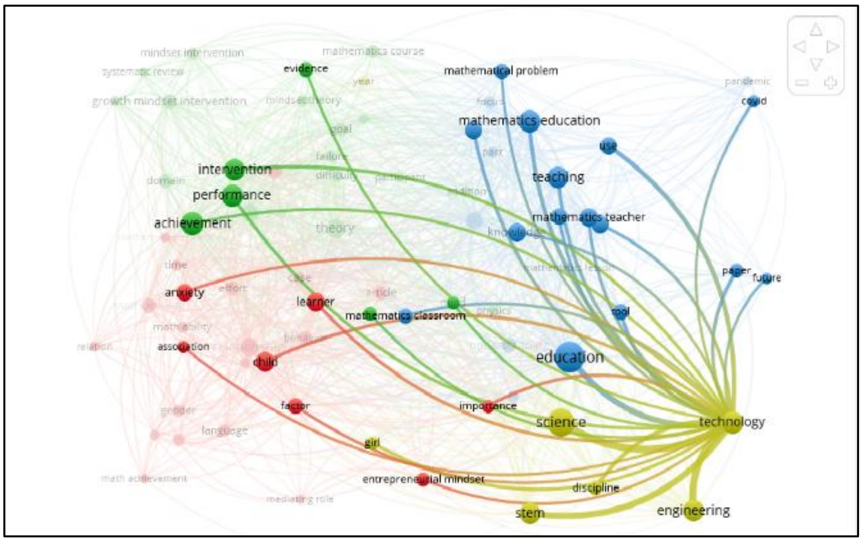

Figure 4. Connection of Technology Term

The second visualization is an overlay visualization (see Figure 5), illustrating trends related to the mathematical mindset each year. The brighter the color, the more prominent the term, which represents the latest trend used in research. In Figure 5, the dark blue term shows the beginning of 2020, and the yellow term shows early 2021. This reinforces the data network visualization, suggesting that mathematical mindset research is not a long-standing trend. The last trend terms related to it are growth mindset intervention, COVID, mediating role, systematic review, discipline, entrepreneurial mindset, and language. Terms such as growth mindset intervention, COVID, and the role of mediation reflect the research response to the impact of the pandemic on mathematics learning, as well as efforts to understand the psycho-pedagogical factors that affect the mathematical mindset (Bakker et al., 2021; Kollosche & Meyerhöfer, 2021). The fading prominence of growth mindset intervention post-2021 coincides with rising terms like systematic review and mediating role, indicating a reflexive, meta-analytical turn.

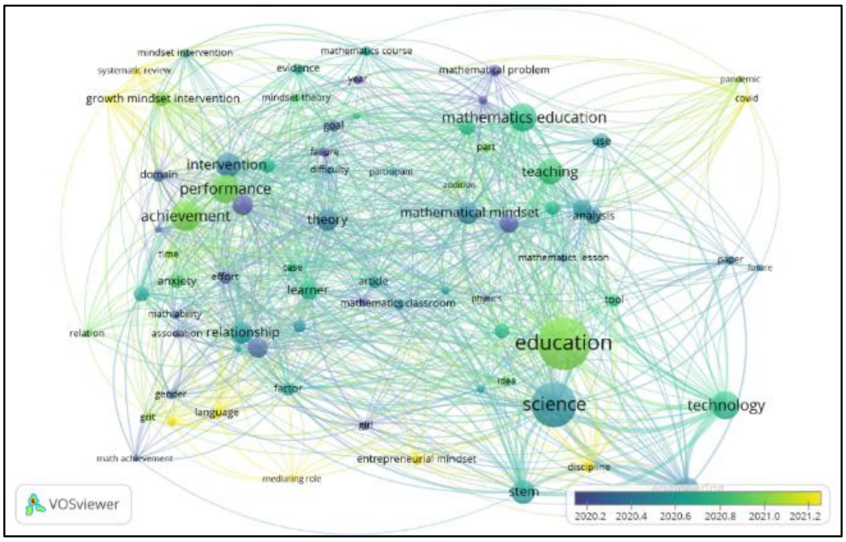

Figure 5. Overlay Visualization of Term in Mathematical Mindset Publication

The last is density visualization, which helps show which terms appear most frequently. The term with the thickest thickness appears the most in the article. *Education* (85 occurrences) and *science* (80 occurrences) dominate density (see Figure 6), emphasizing pragmatic applications over theoretical innovation. This aligns with global policy trends prioritizing STEM workforce development over cognitive psychology (Zhan et al., 2022) but risks reducing mindset theory to a buzzword devoid of mechanistic depth.

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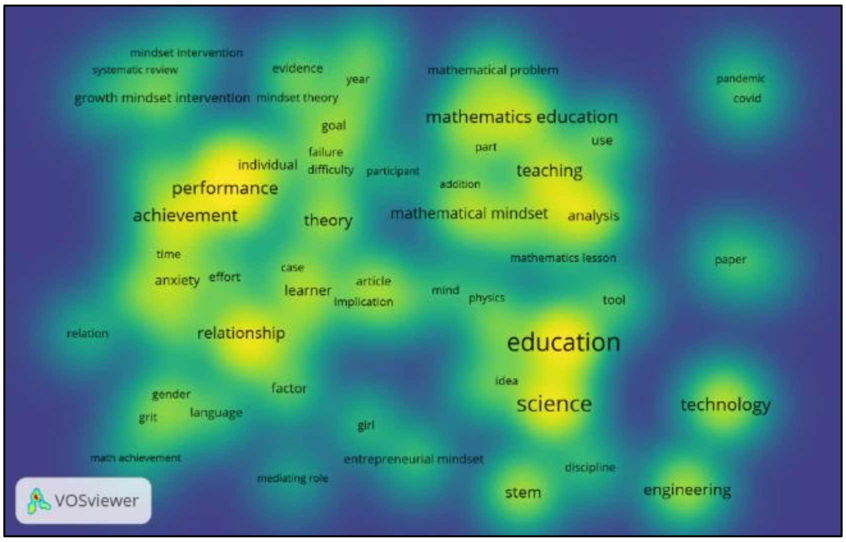

Figure 6. Density Visualization per Item in the Mathematical Mindset Publication

Finally, this research presents new themes that previous reviews have not captured, specifically the unexplored connections between "mathematical mindset" and "technology." It clarifies that the post-2020 publication dip has been induced by the COVID-19 shift to remote pedagogies, wider funding reallocations, and the emergence of AI-driven learning tools. This study also shows that mathematical mindset research has not yet connected well with digital teaching methods. It presents a strong interdisciplinary argument for revitalizing the field of study and empowering educators through adaptive and easy-to-implement strategies. For example, there is the potential to integrate artificial intelligence-based problem-solving exercises in each meeting, followed by writing a reflective journal to strengthen students' growth mindset. Moreover, quantitative findings and student testimonies highlight the term "relationship" as the most central element in Cluster 1, unlocking the potential for collaboration through peer mentoring to strengthen trust between students and educators.

CONCLUSION

This study analyzes publication trends and research mapping on *mathematical mindset* indexed in Google Scholar from 2019 to 2025 using bibliometric analysis. The study's results showed a drastic decrease in the number of publications, with a peak of 272 publications in 2020, followed by a consistent decline until only three publications remained in early 2025. Despite the declining publication trend, Jo Boaler's book *Mathematical Mindsets: Unleashing Students' Potential through Creative Mathematics, Inspiring Messages, and Innovative Teaching* remains the publication with the highest number of citations. The VOSviewer analysis identified four research clusters, with the *mathematical mindset* in the third cluster. In addition, it found weak potential linkages with *technology*. The weak connection between "mathematical mindset" and "technology" signals untapped potential for integrating adaptive learning tools (e.g., AI tutors, gamified platforms) to address post-pandemic engagement challenges.

This research has two limitations. First, database bias is a concern, as reliance on Google Scholar risks inflated citations from grey literature and non-English studies, while excluding co-authorship analysis obscures important insights. Second, the February 2025 data cutoff underestimates annual output. Future directions should include comparing multiple databases (e.g., Scopus/WoS), bibliographic coupling to map the knowledge flow, and ethnographic studies that would put the theoretical content of mindset theory into cultural narratives. It will also involve interdisciplinary collaborations with AI developers, cognitive scientists, and contemporary frameworks.

Even though the number of publications is decreasing, research on mathematical mindsets continues to carry weight. It will be relevant to a 21st-century audience facing issues such as integrating AI with education and the persistent gap along the lines of inequity. As such, it could evolve from a semi-static concept of pedagogy of the 2010s into a far more dynamic framework for fostering mathematical resilience if combined with theoretical underpinnings, technological innovations, and cross-cultural perspectives. This future holds great hope and optimism in education. Mindset researchers need to deal with fragmentation among clusters, disciplines, and regions and revive the urgency of mindset scholarship in an age of rapid educational transformation.

FUNDING STATEMENT

This work received no specific grant from any public, commercial, or not-for-profit funding agency.

AUTHOR CONTRIBUTIONS

Yusuf Adhitya: Conceptualization, writing - original draft, editing, and visualization; **Nurmala Setianing Putri:** Writing - review & editing, formal analysis, and methodology; **Bill Chairy Rizki Bustaren:** Validation and Supervision;
Muhammad Sulthon Ilmiawan: Visualization and Validation.

 http://doi.org/10.30762/f_m.v8i1.4931

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Conflict of Interest Statement: The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.