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TRENDS ON SELF-REGULATED LEARNING IN MATHEMATICS LEARNING: A BIBLIOMETRIC ANALYSIS (2016–2025)

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Abstract :

This study aims to map the global research trends on Self-Regulated Learning (SRL) in mathematics learning during the 2016–2025 period through bibliometric analysis. The scope of the study includes publication patterns, the most frequently studied research topics, and the most productive researchers and institutions. Data were obtained from the Scopus database using the keywords "Self-Regulated Learning" AND "Mathematics Learning" in the title, abstract, and keywords fields, yielding 63 publications that were analyzed using Microsoft Excel and VOSviewer. The results indicate an overall upward trend in publications, peaking in 2024 (13 documents), and a surge in citations from 5 in 2019 to 173 in 2025. Indonesia was the most productive country with 28 publications, followed by China (9) and Hong Kong (7). Guo, W. and Wei, J. were the most productive authors, while the Australian Journal of Education recorded the highest number of citations. Keyword mapping identified four thematic clusters: learning systems, educational technology, e-learning, and learning strategies and reflection. The study's conclusions affirm that SRL in mathematics learning is evolving toward the Technology-Enhanced Self-Regulated Learning paradigm and recommend future research exploring the integration of SRL with artificial intelligence as well as broader international research collaboration.

Keywords : *Self-Regulated Learning, Mathematics Learning, Bibliometric Analysis*

INTRODUCTION

Mathematics plays a central role in education, serving as the foundation for scientific thinking, problem-solving, and decision making across various disciplines (Maass et al., 2019). Despite its strategic importance, students at various educational levels continue to face persistent difficulties in mastering mathematical concepts. Říčan et al., (2022) suggest that student performance in mathematics is significantly shaped by metacognitive knowledge and self-efficacy, both of which act as important mediators between cognitive competence and actual achievement. Similarly, Cevikbas et al., (2024), through a meta-review and bibliometric analysis, report an emerging trend in mathematics learning research addressing the complex interactions among affective, cognitive, and instructional variables, signaling a shift in the field toward a more holistic and student-centered framework. At the global level, international assessments such as PISA and TIMSS have repeatedly documented very low mathematics proficiency among secondary school students in many countries, reflecting systemic challenges in teaching and learning. The rise of digital learning environments following the COVID-19 pandemic has further complicated

students' mathematics learning pathways, revealing gaps in students' ability to maintain academic engagement without direct teacher supervision (Fauzi, 2023). Collectively, these developments underscore the urgent need for research-based strategies that can empower students to become active and autonomous regulators of their own learning processes in mathematics.

Self-Regulated Learning (SRL) refers to a dynamic and iterative process in which learners proactively set goals, select appropriate cognitive and metacognitive strategies, and monitor and evaluate the effectiveness of their learning (Mahrufah & Rijanto, 2024; Zimmerman, 2002). Dörrenbächer-Ulrich et al., (2024) suggest that SRL is closely related to executive functions such as planning, self-control, and cognitive monitoring, which play a crucial role in learning success. In the context of online learning, Dai et al., (2022) identified distinct SRL profiles among middle school students and demonstrated that perceived academic control partially mediates the relationship between SRL and engagement in online mathematics learning during the COVID-19 pandemic. Furthermore, a meta-analysis conducted by Zhao et al., (2025) found that SRL strategies have a significant positive correlation with academic achievement in online and blended learning environments, thereby reinforcing the position of SRL as a key factor in improving the quality of learning. This thus confirms that SRL is not a peripheral variable but a key determinant of the quality of mathematics learning, requiring ongoing scientific attention.

Although there is a growing body of empirical research on SRL in mathematics, there remains a critical gap in the literature regarding a comprehensive, data-driven understanding of how research on this topic has evolved over the decade spanning 2016 to 2025. Existing bibliometric studies have examined SRL within a broad educational context. For example, Dalimunthe et al., (2026) conducted a bibliometric review of SRL, identifying SRL within the context of psychology. Similarly, Oktaviani & Kuswandi, (2024) examined trends in SRL, limiting the scope to Indonesia. The research by Widia et al., (2026) examined trends in SRL within the broader field of education. Furthermore, a bibliometric mapping analysis by Nuryadin et al., (2024) analyzed SRL publications in STEM education indexed in Scopus from 2013 to 2023, reporting that SRL research related to mathematics is a relatively less dominant sub-theme within the broader SRL STEM corpus.

Gaps in previous research have opened up further avenues for this study. While previous bibliometric reviews have extensively examined SRL across various educational contexts or within STEM disciplines, none have exclusively focused on mathematics learning as the primary domain of inquiry over the past decade a period encompassing the critical pre-pandemic, pandemic, and post-pandemic phases of educational transformation. Based on these research gaps, this study is guided by the following research questions: (1) What are the publication and citation patterns of SRL research in mathematics learning from 2016 to 2025? (2) How are publications distributed by geographic region? (3) Who are the most productive researchers and institutions contributing to the SRL mathematics learning literature? (4) What are the most frequently studied topics and thematic groups in SRL research in mathematics learning, as revealed through co-occurrence analysis of keywords? Therefore, the objectives of this

study are to identify publication patterns, the most frequently researched topics, and the most productive researchers and journals. By systematically addressing these questions, this study provides a comprehensive, evidence-based map of the SRL-mathematics learning research landscape, thereby supporting informed guidance for future empirical and theoretical investigations.

RESEARCH METHOD

This study employs a bibliometric approach to map the global research trends on Self-Regulated Learning in Mathematics Learning during the 2016–2025 period. Bibliometric analysis is a widely used quantitative method for evaluating the intellectual structure, publication patterns, and development of a scientific field through the analysis of scientific publication metadata (Kirby, 2023). The research data were obtained from the Scopus database, which has the advantage that its publications undergo a peer-review process, making it the most comprehensive database for peer-reviewed publications (Julius et al., 2021). The literature search was conducted on June 9, 2026, using the keywords "Self-Regulated Learning" AND "Mathematics Learning" in the title, abstract, and keywords fields. Only studies published between 2016 and 2025 were included in this study. All data were subsequently exported in CSV format for further analysis. Bibliometric analysis was performed using Microsoft Excel and VOSviewer, software widely used to visualize bibliographic relationships, collaboration patterns, and the conceptual structure of a research field through an analytical approach. By combining these two tools, a comprehensive overview of SRL in mathematics learning from 2016 to 2025 can be provided.

FINDINGS AND DISCUSSION

Distribution of Publications by Document Type

A search conducted on June 9, 2026, yielded 63 publications, which were divided into 4 document types, as shown in Table 1. The majority of the publications consisted of 40 (63.5%) articles and 21 (33.3%) conference papers. Meanwhile, the other two document types conference reviews and reviews each accounted for 1 (1.6%).

Table 1. Distribution of Publications by Document Type

Rank	Type of Publication	F	%
1	Article	40	63.5
2	Conference Paper	21	33.3
3	Conference Review	1	1.6
4	Review	1	1.6

Distribution of Publications and Citations

The distribution of these publications by year of publication is shown in Figure 1.

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Document	1	0	3	4	9	9	9	7	13	8
citation	0	0	0	5	17	31	49	53	110	173

Figure 1. Distribution of Publications and Citations

As shown in Figure 1, at the beginning of the period, the number of publications was still relatively low, with only one document in 2016 and no publications found in 2017. Subsequently, the number of publications increased gradually, reaching 9 documents in 2020 and remaining stable through 2022. After a slight decline to 7 documents in 2023, the number of publications increased significantly in 2024 to 13 documents, the highest number during the observation period. Meanwhile, 2025 recorded 8 documents. Overall, publications on SRL in mathematics learning during the 2016–2025 period tended to increase despite some fluctuations. This indicates that SRL has evolved into one of the key themes in mathematics learning research.

In terms of citations, there has been a far more significant increase compared to the growth in publications. The number of citations rose from 5 in 2019 to 173 in 2025, indicating that SRL research in mathematics learning is having an increasingly strong scientific impact and is frequently cited by other researchers. The high accumulation of citations in a relatively small number of publications indicates that this field has a high academic impact and growing relevance within the education research community. The combination of an increase in the number of publications and a surge in citations suggests that SRL research in mathematics learning is not only growing in terms of quantity but is also becoming more mature and influential in terms of quality and scientific contribution.

Distribution of Publications by Geographic Region

This study found that 23 countries have published research on the topic of SRL in mathematics learning. The distribution List of 10 countries with the most publications is shown in Figure 2.

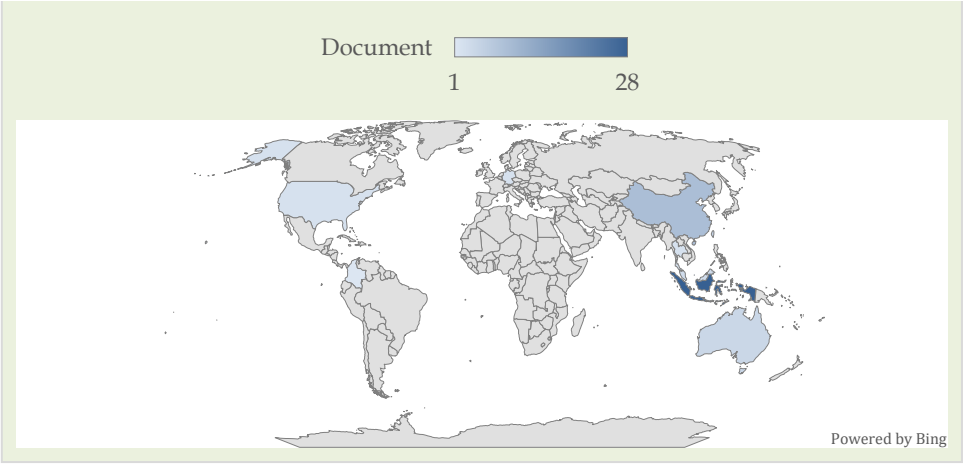
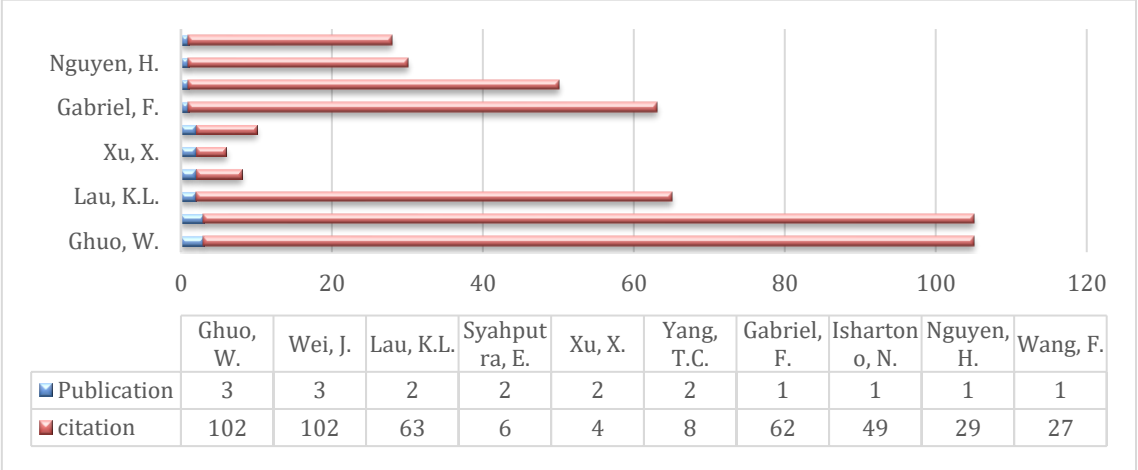


Figure 2. Distribution List of 10 countries with the most publications

As shown in Figure 2, it is clear that publications on this topic are not evenly distributed across all countries. Among the top 10 countries with the most publications, Indonesia ranks first with 28 publications, far surpassing other countries such as China (9 publications), Hong Kong (7 publications), Taiwan (5 publications), Australia (4 publications), Malaysia (3 publications), as well as Germany, Thailand, and the United States, each with 2 publications, as well as Colombia (1 publication). Indonesia's dominance indicates that research on SRL in mathematics learning is receiving significant attention within the Indonesian academic community. This phenomenon can be linked to the various challenges in mathematics learning that Indonesia still faces, such as the need to enhance students' SRL skills to meet the demands of 21st-century learning (Saputra, 2024).

Most Productive and Most Cited Authors

To identify the most influential publications, a citation analysis was conducted to determine the number of citations received by each article. Considering the number of publications and citations is one of the most popular methods frequently used in bibliometric studies (Merigó et al., 2015). The Prolific and Highly Cited Authors is shown in Figure 3.



	Ghuo, W.	Wei, J.	Lau, K.L.	Syahputra, E.	Xu, X.	Yang, T.C.	Gabriel, F.	Isharto o, N.	Nguyen, H.	Wang, F.
Publication	3	3	2	2	2	2	1	1	1	1
citation	102	102	63	6	4	8	62	49	29	27

Figure 3. Prolific and Highly Cited Authors

Based on Figure 3, the analysis of the most productive authors shows that

Ghuo, W. and Wei, J. are the authors with the highest number of publications, each with 3 documents totaling 102 citations. However, the results also indicate that the number of publications does not always correlate directly with the number of citations received. Some authors with fewer publications, such as Xu, X. (2 publications; 63 citations) and Gabriel, F. (1 publication; 62 citations), were able to generate relatively high scientific impact. This finding indicates that the influence of a study is determined more by its quality, relevance, and conceptual contribution than by the mere number of publications. This phenomenon aligns with Lotka's Law, which explains that only a small fraction of authors are capable of making significant contributions to the advancement of science, and is supported by the Matthew Effect theory, which states that scientific works that have already gained recognition tend to be cited more frequently (Lotka, 1926; Merton, 1968). Thus, authors with a high number of citations can be considered key contributors to the establishment and development of research on SRL in mathematics learning.

Most Cited Journals

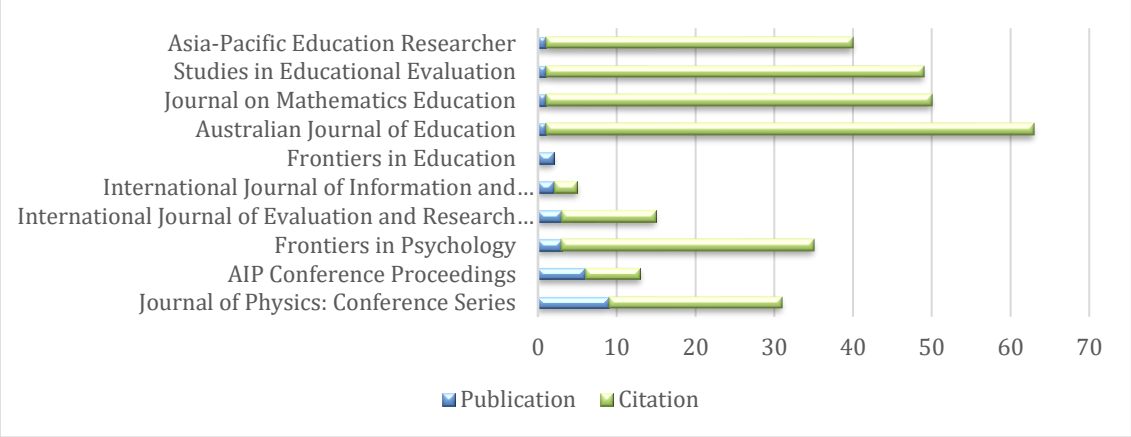


Figure 4. Most Cited Journals

Based on Figure 4 the *Journal of Physics: Conference Series* (JPCS) was the most productive source with 9 publications and 22 citations, followed by *AIP Conference Proceedings* with 6 publications and 7 citations. The high number of publications in these two proceedings indicates that research on SRL in mathematics learning is frequently published through conference forums, which generally serve as an initial medium for disseminating research findings. However, despite the high number of publications, their scientific impact is relatively lower compared to some reputable journals with fewer articles. For example, the Australian Journal of Education has only 1 publication but received 62 citations, while the Journal on Mathematics Education received 49 citations, Studies in Educational Evaluation received 48 citations, and the Asia-Pacific Education Researcher received 39 citations from each respective publication. These findings suggest that journal productivity does not always align with its level of scientific influence.

In bibliometric studies, the number of citations is often used as an

indicator of the quality, visibility, and influence of a publication within the academic community (Donthu et al., 2021). The high citation rates in reputable educational journals indicate that articles published in these journals make stronger theoretical and empirical contributions, leading to their frequent use as references by other researchers. Thus, the development of SRL research in mathematics learning is marked not only by the large number of publications in conference proceedings but also by the strong scientific impact of articles published in reputable international education journals

The Research Focuses Based on Keywords Used in the Publications

The keyword network diagram generated by VOSviewer visualizes the relationships between keywords from data drawn from 63 publications. As shown in Figure 5, "Network Visualization of Co-occurrence Keywords" generated by VOSviewer, the keyword "self-regulated learning" is the largest and most central node in the network. The large size of the node indicates a high frequency of occurrence, while the numerous connecting lines suggest that this concept has strong ties to various other research topics. This keyword is closely linked to "mathematics learning," "students," "learning systems," "mathematics education," "e-learning," "learning strategies," and "reflection." This central position suggests that SRL research in mathematics learning is evolving as a multidimensional theme that addresses not only students' self-regulation abilities but also their connections to learning strategies, digital learning environments, and the reflection process. This finding aligns well with Zimmerman's SRL cycle model, which explains that the learning process consists of three main phases: planning, monitoring and control, and evaluation of learning outcomes. This indicates that Zimmerman's model remains the most widely used theoretical foundation in SRL research, particularly because it comprehensively explains the relationship between learning strategies, motivation, and student learning outcomes (Tinajero et al., 2024). Network Visualization of Co-occurrence Keywords is shown in Figure 5.

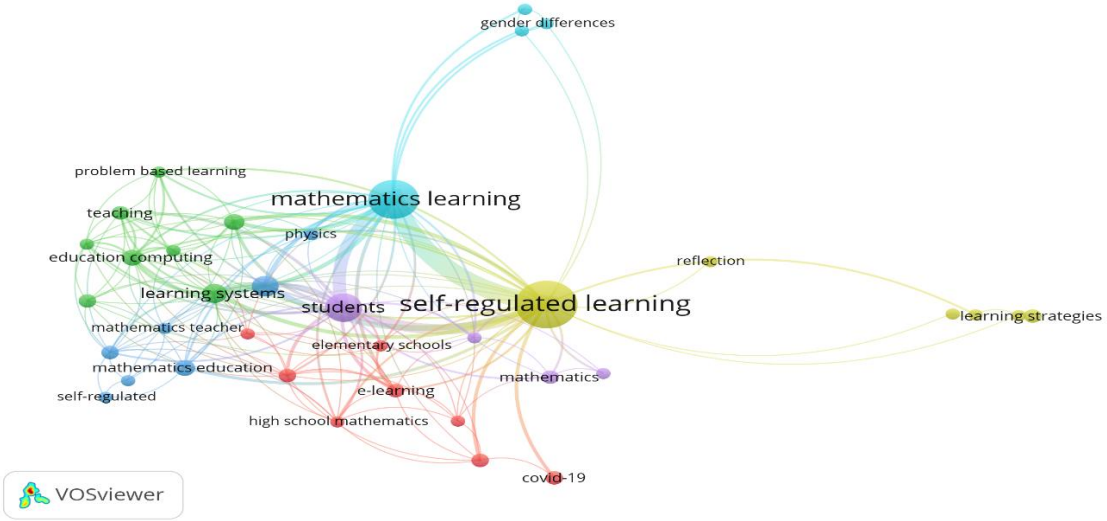


Figure 5. Network Visualization of Co-occurrence Keywords

Based on Figure 5, The visualization also reveals several research clusters that reflect different areas of focus. The blue cluster centers on keywords such as

"mathematics learning," "mathematics education," and "physics," indicating that SRL is frequently studied within the context of STEM discipline learning. The green cluster, comprising "learning systems," "teaching," "educational computing," and "problem-based learning," indicates that SRL research is developing within the context of instructional design and the integration of educational technology. The relationship between SRL and problem-based learning (PBL) can be explained through constructivist theory, which states that effective learning occurs when students actively construct their knowledge through the resolution of authentic problems (Lathifah et al., 2024). In a PBL environment, self-regulation skills are crucial because students must plan strategies, monitor progress, and evaluate the resulting solutions independently (Annisa et al., 2026).

In addition, there is a red cluster containing the keywords "COVID-19" and "e-learning," indicating the emergence of research themes influenced by changes in the post-pandemic learning environment. During and after the pandemic, research on SRL has grown rapidly because online learning requires students to manage their time, motivation, and learning strategies more independently (Lestari, 2021; Tnunay et al., 2025). This phenomenon also explains why themes related to learning technologies and digital learning systems emerge as one of the key clusters in the network visualization.

Interestingly, the keyword "gender differences" emerged as a subtheme directly linked to mathematics learning and SRL, despite being relatively separated from the main cluster. This indicates that some research aims to explore variations in self-regulation abilities based on gender in mathematics learning. According to Bandura (1986) differences in learning experiences, self-efficacy, and environmental factors can influence the self-regulation strategies used by students. Therefore, the gender aspect is one of the factors considered in understanding the effectiveness of SRL in the context of mathematics.

Overall, this network map shows that research on SRL in mathematics learning has developed through four themes: (1) learning systems, (2) educational technology, (3) e-learning, and (4) learning strategies, reflection, and learner characteristics. The dominance of the keywords "self-regulated learning" and "mathematics learning" indicates that research in this field remains focused on efforts to understand how students manage the process of learning mathematics independently. However, the emergence of keywords such as "learning systems," "educational computing," and "e-learning" suggests a shift toward the Technology-Enhanced Self-Regulated Learning (TESRL) paradigm, an approach that integrates SRL theory with digital technology, learning analytics, and artificial intelligence to support more adaptive and personalized learning processes. Thus, this visualization suggests that future research is likely to increasingly integrate SRL with smart technologies to enhance the effectiveness of mathematics learning.

CONCLUSION

This study confirms that Self-Regulated Learning (SRL) in mathematics

learning has emerged as an increasingly significant and influential research topic in the global discourse on mathematics learning during the 2016–2025 period. A bibliometric analysis of 63 publications in the Scopus database reveals a growth pattern that, while not entirely linear, overall shows a steadily increasing trajectory. The peak in productivity was recorded in 2024 with 13 publications, reflecting an acceleration in researchers' interest in this topic, particularly in response to changes in the post-COVID-19 learning ecosystem. The surge in citations was far more dramatic, rising from 5 citations in 2019 to 173 citations in 2025. This reinforces the conclusion that the development of this field is not merely quantitative but also reflects a deepening of quality and tangible scientific impact for the international mathematics learning research community. In terms of geographic distribution, Indonesia emerged as the dominant contributor with 28 out of 63 publications, far surpassing China and Hong Kong. This dominance reflects a high level of academic awareness in Indonesia regarding the urgency of strengthening student autonomy in learning within the context of 21st-century mathematics learning.

An analysis of author productivity reveals that scientific impact is not always directly proportional to the quantity of publications. Internationally reputable education journals have been shown to have significantly higher scientific impact than conference proceedings, confirming that the visibility and theoretical contribution of a study are more determined by the quality of the publication medium. Keyword network mapping highlights a multidimensional structure. The emergence of thematic clusters relates to learning systems, learning strategies, reflection, student characteristics, educational technology, and e-learning. This marks a paradigmatic shift toward Technology-Enhanced Self-Regulated Learning (TESRL). This study recommends that future research explore in greater depth the integration of SRL with intelligent learning technologies, enhance international research collaboration for broader generalizability, and develop longitudinal and experimental studies measuring the long-term impact of SRL interventions on mathematical competence. Thus, the intellectual map generated by this research is expected to serve as a solid foundation for the development of a more innovative, collaborative, and impactful SRL research agenda in mathematics learning.

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