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Research trends on RME and self-confidence in the Mathematics education curriculum

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ABSTRACT

Realistic Mathematics Education (RME) has been recognized as an innovative approach that effectively improves mathematical skills and students' self-confidence. This study aims to analyze scientific trends related to the application of RME and its impact on self-confidence in mathematics education curriculum. A bibliometric approach was used to analyze 200 articles published between 2020-2024. Data were obtained using the Publish or Perish tool and analyzed with VOSviewer to evaluate citation metrics, collaboration patterns between authors, and relationships between keywords. The analysis results showed 2,314 citations with an average of 11.57 citations per article and active collaboration patterns with an average of 2.6 authors per article. This study found that the Realistic Mathematics Education (RME) approach significantly increased students' confidence in learning mathematics and improved problem-solving skills and in-depth concept understanding. The bibliometric analysis showed that research topics related to RME and student confidence have received extensive academic attention, with high citation rates and significant contributions to the development of mathematics education theory and practice. The findings confirm the importance of RME as an innovative approach in supporting students' cognitive and affective learning outcomes while providing a basis for developing mathematics education practice.

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ABSTRAK

Realistic Mathematics Education (RME) telah dikenal sebagai pendekatan inovatif yang efektif dalam meningkatkan kemampuan matematis sekaligus kepercayaan diri (self-confidence) peserta didik. Penelitian ini bertujuan untuk menganalisis tren ilmiah terkait penerapan RME dan dampaknya terhadap self-confidence dalam kurikulum pendidikan Matematika. Pendekatan bibliometrik digunakan untuk menganalisis 200 artikel yang diterbitkan pada rentang waktu 2020-2024. Data diperoleh menggunakan perangkat Publish or Perish dan dianalisis dengan VOSviewer untuk mengevaluasi metrik sitasi, pola kolaborasi antarpenulis, dan hubungan antar kata kunci. Hasil analisis menunjukkan total 2.314 sitasi dengan rata-rata 11,57 sitasi per artikel, serta pola kolaborasi aktif dengan rata-rata 2,6 penulis per artikel. Penelitian ini menemukan bahwa pendekatan Realistic Mathematics Education (RME) secara signifikan meningkatkan kepercayaan diri siswa dalam pembelajaran Matematika, selain meningkatkan kemampuan pemecahan masalah dan pemahaman konsep secara mendalam. Analisis bibliometrik menunjukkan bahwa topik penelitian terkait RME dan kepercayaan diri peserta didik telah mendapatkan perhatian akademik yang luas, dengan tingkat sitasi yang tinggi dan kontribusi signifikan terhadap pengembangan teori dan praktik pendidikan Matematika. Temuan ini menegaskan pentingnya RME sebagai pendekatan inovatif dalam mendukung hasil belajar kognitif dan afektif peserta didik, sekaligus memberikan dasar bagi pengembangan praktik pendidikan Matematika.

Kata Kunci: *analisis bibliometrik; kepercayaan diri; pendidikan matematika; realistic mathematics education; RME*

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INTRODUCTION

Mathematics is a discipline that plays a critical role in developing logical, critical, and analytical thinking skills. In an ever-evolving era of globalization, the need for mathematics learning relevant to real-life contexts has become increasingly urgent. Realistic Mathematics Education (RME) has emerged as a learning approach emphasizing real-world contexts in teaching mathematical concepts, enabling students to understand mathematics more deeply and meaningfully (Juandi et al., 2022). As a problem-based approach, RME aims to connect mathematics with students' everyday lives, enhancing conceptual understanding and fostering more potent problem-solving abilities (Anggraini & Fauzan, 2020).

Beyond cognitive abilities, the success of mathematics learning also heavily depends on affective aspects, one of which is self-confidence. Self-confidence is vital in determining students' success, as confident students are more likely to take intellectual risks and overcome challenges in the learning process (Psaras et al., 2020). Research shows that self-confidence affects students' academic achievements and shapes their future attitudes toward mathematics (Berlian et al., 2023). Therefore, exploring how learning approaches like RME can contribute to developing students' self-confidence is crucial.

The RME approach has been widely applied in the context of mathematics education curriculums in various countries, including Indonesia. For instance, the 2013 Curriculum emphasizes learning oriented toward 21st-century skills, such as critical thinking, creativity, communication, and collaboration (4C). The RME approach aligns with these objectives, effectively integrating these skills into mathematics learning (Minarni & Napitupulu, 2020). However, although this approach has proven effective in enhancing mathematical abilities such as creative thinking and problem-solving (Juandi et al., 2022; Maskur et al., 2020), the literature specifically examining RME's contribution to affective aspects, such as students' self-confidence, remains scarce.

A review of the literature reveals several key findings. The first research shows that the RME approach effectively improves students' problem-solving abilities but does not delve deeply into affective aspects (Anggraini & Fauzan, 2020). Another study highlights the development of RME-based learning tools oriented toward mathematical connection abilities and self-confidence. Still, its primary focus is on cognitive aspects (Sucahyo et al., 2021). The third study found that learning materials based on model-eliciting activities have the potential to enhance students' problem-solving abilities and self-confidence (Berlian et al., 2023). However, their application within the RME context has not been comprehensively explored. Based on this review, there is a significant research gap. Most studies focus on the cognitive aspects of RME, while its affective impact, particularly on students' self-confidence, has received insufficient attention. Additionally, there is a lack of research integrating bibliometric analysis to explore research trends on RME and its impact on self-confidence within the mathematics education curriculum.

This study addresses these gaps by analyzing research trends on RME and its influence on students' self-confidence. Using a bibliometric approach, this research seeks to identify patterns of author collaboration, dominant themes, and the development of topics over time. This study's findings are expected to significantly contribute to the development of the literature and the practice of mathematics education, particularly in fostering holistic and contextually relevant learning that meets students' needs.

LITERATURE REVIEW

Research on Realistic Mathematics Education (RME) and its effect on self-confidence in mathematics education curriculum has gained increasing attention recently. The RME approach, introduced by Freudenthal, emphasizes using real contexts in mathematics teaching to make it more meaningful to students. This pedagogical framework promotes students' conceptual understanding and aligns with the

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global trend toward student-centered and problem-based learning models. A problem-based learning approach is a learning approach that is student-centered, allowing them to confront real-world problems, encouraging critical thinking, collaboration, and problem-solving (Handoyo et al., 2024). Along with the adoption of competency-based curriculum by various education systems, including Curriculum 2013 in Indonesia, studies have shown the role of RME in achieving cognitive and affective outcomes, such as self-confidence (Berlian et al., 2023; Juandi et al., 2022).

A bibliometric analysis of recent research shows increased publications related to RME and self-confidence, focusing on its theoretical basis, practical implementation, and outcomes in various educational contexts. For example, research by Juandi et al. (2022) and Nguyen & Pham (2023) highlight the effectiveness of RME in improving mathematical literacy and reasoning. However, despite this growing interest, empirical evidence linking RME to affective outcomes such as self-confidence is still limited. This gap suggests the need to explore further how RME can holistically address cognitive and psychological needs in mathematics learning.

Realistic Mathematics Education (RME)

RME is a pedagogical approach rooted in the idea that mathematics should be taught as an activity closely related to actual experiences. This approach encourages students to discover mathematical concepts through guided discovery and exploration of contextual problems (Juandi et al., 2022). Using real contexts makes abstract mathematical ideas easier to understand and meaningful to students, thus helping them develop critical thinking and problem-solving skills (Anggraini & Fauzan, 2020). Realistic Mathematics Education (RME) has positively impacted various aspects of students' mathematical abilities. This is reflected in several studies that show the effectiveness of this approach in improving students' concept understanding, problem-solving skills, and mathematical connections. RME mainly focuses on exploring contextual problems and actual experience-based learning activities, making it easier for students to understand and apply mathematical concepts in everyday life.

The RME approach has improved students' problem-solving ability, an essential higher-order thinking skill required in various aspects of life and career. This approach directs students to solve problems systematically and logically, allowing them to understand the steps involved and explain the reasons behind their solutions (Anggraini & Fauzan, 2020). In addition, RME-based learning tools are oriented towards improving students' mathematical connections, which involves linking various mathematical concepts across topics and connecting them to real-life situations. These learning tools have also been reported to increase students' confidence, as strong mathematical connection skills empower students to apply their mathematical knowledge effectively, which in turn can improve their overall learning performance. Adapting the RME approach to diverse educational contexts has also been demonstrated. For example, an RME-based interactive e-module designed for primary school students improves mathematical literacy by using technology to present contextual problems relevant to students' experiences (Aulia & Prahmana, 2022). Similarly, the application of RME in learning in elementary schools has been shown to improve mathematical understanding and foster student confidence in solving mathematical problems (Sucahyo et al., 2021).

Self-Confidence in Mathematics Learning

Self-confidence is one of the affective factors that play an essential role in successful mathematics learning. As a psychological aspect, self-confidence refers to students' belief in their ability to complete academic tasks, including mathematical challenges that many students often find difficult (Psaras et al., 2020). In mathematics learning, self-confidence influences students' willingness to try to solve complex

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problems. It affects their perseverance in the face of difficulties, ability to learn from mistakes, and openness to new learning methods (Berlian et al., 2023). Students with high self-confidence tend to have a positive attitude towards mathematics, which impacts increasing motivation and resilience in learning. This motivation encourages students to be more active in learning, take the initiative to solve problems, and persevere in the face of failure until they find the correct solution. Research by Psaras et al. (2020) shows that self-confidence acts as a catalyst in learning, as confident students tend to be more willing to take intellectual risks, such as trying new strategies or solving challenging problems, than students with low self-confidence.

Students' self-confidence is influenced by various factors, including the learning approach used, such as Realistic Mathematics Education (RME), which helps students understand the material contextually to increase their confidence in solving mathematical problems (Sucahyo et al., 2021). In addition, good mathematical thinking and problem-solving skills also contribute significantly, especially when students are given relevant challenges and successfully solve them (Psaras et al., 2020). Mathematical communication skills are also essential for students' success in problem-solving, critical thinking, idea articulation, and addressing challenges (Muhdiati et al., 2025). Using interactive learning media, such as RME-based e-learning modules, also encourages self-confidence by strengthening students' understanding of the material. Furthermore, self-regulated learning or independence in learning allows students to control their learning process, positively impacting their self-confidence (Siregar et al., 2023). Support from the learning environment, including teachers and peers, provides a sense of security for students to learn without fear of failure, while successful experiences in completing meaningful tasks further strengthen their self-confidence (Hutasuhut et al., 2024). Thus, optimizing these factors can create learning conditions that empower students.

Self-confidence affects academic achievement and has been the focus of many studies. Students with high self-confidence tend to be more motivated to learn, able to face academic challenges, and show resilience in coping with learning pressure (Sucahyo et al., 2021). In contrast, low self-confidence often correlates with learning anxiety, lack of participation, and a tendency to avoid challenges that could improve their skills (Ahmad et al., 2023). Through supportive learning approaches, such as Realistic Mathematics Education (RME), students' confidence can be significantly improved as this approach provides learning experiences that are contextual and relevant to everyday life (Berlian et al., 2023). Therefore, educators need to create an environment that supports the development of student's confidence to optimize their academic potential. Further research is needed to find more effective learning strategies for building students' self-confidence at various levels of education.

Mathematics Education Curriculum

The mathematics education curriculum has undergone significant changes to address the needs of the 21st century, focusing on developing critical thinking, creativity, communication, and collaboration skills (Minarni & Napitupulu, 2020). In Indonesia, Curriculum 2013 explicitly adopts a student-centered competency-based learning approach, where Realistic Mathematics Education (RME) is considered a suitable pedagogical strategy to support these skills (Maskur et al., 2020). The RME approach emphasizes using realistic contexts to help students understand mathematical concepts meaningfully. Research shows that RME contributes significantly to developing mathematical reasoning and problem-solving skills, essential elements in modern education (Juandi et al., 2022). In addition, this approach also supports mathematical literacy by allowing students to connect abstract mathematical concepts with real-life situations (Arnawa & Fauzan, 2023). However, implementing an RME-oriented curriculum faces challenges integrating affective objectives. Aspects such as students' confidence and motivation are often overlooked, even though these factors play an essential role in successful learning (Juandi et al., 2022).

https://doi.org/10.17509/jik.v22i1.79455

Thus, more integrated strategies are needed to ensure that cognitive and affective aspects receive equal attention in curriculum design and implementation.

METHODS

This study uses a bibliometric approach to analyze research trends related to Realistic Mathematics Education (RME) and self-confidence in the mathematics education curriculum. This approach was chosen because it can provide a comprehensive picture of the development of scientific literature, collaboration patterns between authors, and dominant research themes (Mejia et al., 2021; Velez-Estevez et al., 2022). Research data were collected through Google Scholar using Publish or Perish (PoP) software, with main keywords such as "realistic mathematics education" AND "self-confidence" AND "curriculum." The analyzed articles were published in 2020-2024, with 200 articles that met the inclusion criteria. The inclusion criteria included articles that focused on RME and self-confidence in the context of mathematics education, were published in internationally indexed journals, and were within the research period. Conversely, articles that did not focus on mathematics education or had incomplete data were excluded from the analysis.

Data analysis was conducted using several main approaches. First, citation analysis was used to measure the quality of research (Haq, 2021) based on the number of citations per article, average citations per year, h-index, g-index, and other metrics. Second, collaboration analysis was conducted to visualize the co-authorship network between authors, collaboration intensity, and research clusters using VOSviewer software. Third, keyword analysis (co-occurrence) was used to map the relationships between keywords to identify dominant themes and research trends based on the frequency of their co-occurrence (Klarin, 2024). The results of the data analysis are visualized in the form of network graphs, density maps, and trend overlays using VOSviewer software. This visualization aims to identify collaboration patterns between authors, emerging themes, and changes in research focus over time. Furthermore, the results are interpreted by referring to related literature and relevant key findings before concluding.

RESULTS AND DISCUSSION

Significance and Relevance of the Research Topic

The citation metrics were generated from Publish or Perish (PoP) by entering the keywords "realistic mathematics education" AND "self-confidence" AND "curriculum". The data shows that the publication range of the articles analyzed is between 2020 and 2024, totaling 200 articles. These articles have received 2,314 citations in 5 years (2020-2025), averaging 462.8 citations per year. The average citation per article is 11.57, indicating that each article has a relatively good level of readability and influence. In addition, the average citation per author reaches 955.72, reflecting the significant contribution of each author to the literature in this field.

Collaboration between authors is also evident from the average of 2.6 authors per article, indicating that most research is conducted in teams. Regarding productivity, each author contributes an average of 96.89 articles, indicating a high publication rate. Regarding quality, the h-index 23 indicates 23 articles with at least 23 citations. At the same time, the g-index of 44 confirms that articles with a high citation rate significantly contribute to the total citations. The hI norm index of 16 and hI annual of 3.2 indicate consistent levels of individual productivity each year, with the hA index of 14 highlighting the most relevant and influential articles.

Furthermore, the citation distribution shows that 94 articles have at least one citation, 64 articles have two or more citations, 33 articles have five or more citations, 20 articles have ten or more citations, and 10

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articles have twenty or more citations. This shows that while most articles have moderate citation rates, a group of articles is starting to receive greater attention in the academic community.

The results of this data analysis indicate that research on Realistic Mathematics Education (RME) and its impact on self-confidence in the Mathematics Education Curriculum has a significant impact on the scientific community. The high level of collaboration, author productivity, and relatively even distribution of citations provide a strong foundation for bibliometric analysis.

Number of Citations and Author Productivity

The number of citations and author productivity are two leading indicators often used to assess the impact and contribution of a researcher in academia. First, authors with high citations usually have a good reputation and are recognized as authorities in their field. The more citations an author's work receives, the greater the influence of the work in the academic community (Caputo et al., 2021). Citations indicate that other researchers consider the work relevant, useful, or essential. Second, productivity is measured by the number of articles, books, or other publications produced. This shows the consistency and commitment of an author to his/her research. An author with few publications but many citations indicate their work is very influential (Blasco-Blasco et al., 2024).

Table 1. List of 10 Authors with the Most Citations

Cites	Authors	Title	Year	Source	Publisher
238	C Attard, K Holmes	An exploration of teacher and student perceptions of blended learning in four secondary mathematics classrooms (Attard & Holmes, 2022).	2022	Mathematics Education Research Journal	Springer
233	RCI Prahmana, U D'Ambrosio	Learning Geometry and Values from Patterns: Ethnomathematics on the Batik Patterns of Yogyakarta, Indonesia (Prahmana & D'Ambrosio, 2020).	2020	Journal on Mathematics Education	ERIC
137	S Suherman, T Vidakovich	Assessment of mathematical creative thinking: A systematic review (Suherman & Vidákovich, 2022).	2022	Thinking Skills and Creativity	Elsevier
119	R Maskur, Y Rahmawati, K Pradana, M Syazali…	The Effectiveness of Problem Based Learning and Aptitude Treatment Interaction in Improving Mathematical Creative Thinking Skills on Curriculum 2013 (Maskur et al., 2020).	2020	European Journal of …	ERIC
83	DH Tong, BP Uyen, NVA Quoc	The improvement of 10th students' mathematical communication skills through learning ellipse topics (Tong et al., 2021).	2021	Helion	cell.com
79	D Juandi, YS Kusumah, M Tamur	A meta-analysis of the last two decades of realistic mathematics education approaches (Juandi et al., 2022).	2022	International Journal of Instruction	e-iji.net
72	T Wijaya, Y Zhou, A Ware, N Hermita	Improving the creative thinking skills of the next generation of mathematics teachers using dynamic mathematics software (Wijaya et al., 2021).	2021	International Journal of …	learntechlib.org
69	S Ndiung, E Jehadus, RA Apsari	The Effect of Treffinger Creative Learning Model with the Use RME Principles on Creative Thinking Skill and Mathematics Learning Outcome (Ndiung et al., 2021).	2021	International Journal of Instruction	ERIC

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Cites	Authors	Title	Year	Source	Publisher
65	A Windasari, B Syefrinando, V Wiliyanti…	The influence of the blended learning model on students' concept understanding ability viewed from self-confidence (Windasari et al., 2024).	2024	AIP Conference …	pubs.aip.org
65	ND Safitri, R Darmayanti, U Usmiyatun…	21st-century mathematics learning challenges: Bibliometric analysis of trends and best practices in Shinta indexed scientific publications (Safitri et al., 2023).	2023	JEMS: Journal …	e-journal.unipma.ac.id

Source: Google Scholar Database, 2024

Table 1 lists the 10 authors with the most citations in mathematics education. The first authors, C. Attard and K. Holmes have the highest number of citations (238) thanks to their work exploring teachers' and students' perceptions of blended learning in mathematics classrooms (Attard & Holmes, 2022). Followed by RCI Prahmana and U D'Ambrosio (233 citations), who studied ethnomathematics in batik patterns in Yogyakarta, Indonesia (Prahmana & D'Ambrosio, 2020). The works in this list also cover other essential topics, such as developing creative mathematical thinking skills (Suherman & Vidákovich, 2022) and improving students' mathematical communication skills through ellipses (Tong et al., 2021). These publications are published in leading journals, such as Mathematics Education Research Journal, Thinking Skills and Creativity, and Heliyon, demonstrating the diversity of topics and approaches in mathematics education.

From this data, it can be interpreted that researchers with high citations tend to choose topics that are relevant to current educational issues, such as blended learning, ethnomathematics, and creative thinking skills (Attard & Holmes, 2022; Prahmana & D'Ambrosio, 2020; Suherman & Vidákovich, 2022). Research combining educational theory with real-world practice, such as the use of technology or creative learning models, has attracted the attention of many other researchers. In addition, these works have broad relevance in theory and application, allowing them to be widely accepted and cited. Research in mathematics education that focuses on innovative approaches, such as technology-based learning and the development of creative thinking skills, has had a significant impact and has had a major influence on the global academic community (Ndiung et al., 2021; Wijaya et al., 2021).

Table 2. Author Productivity Data

No.	Author	Number of docs.	Institution/ Country	Title
1	Prabhu, R.A.	4	Ahmad Dahlan University, Yogyakarta, Indonesia	• Developing interactive e-module based on realistic mathematics education approach and mathematical literacy ability (Aulia & Prahmana, 2022). • Learning Geometry and Values from Patterns: Ethnomathematics on the Batik Patterns of Yogyakarta, Indonesia (Prahmana & D'Ambrosio, 2020). • The theoretical framework on humanist ethno-metaphorical mathematics learning model: An impactful insight in learning mathematics (Hendriana et al., 2022). • Designing the learning trajectory for the topic of circles through a tambourine context (Juniarti et al., 2022)
2	Fauzan, Ahmad	3	Padang State University, Indonesia	• The Feasibility of PBL-Reathnomath Model to Train Hots Of Elementary School Students (Anggraini & Fauzan, 2020). • The effect of realistic mathematics education approach on mathematical problem-solving ability (Rahman et al., 2020).

https://doi.org/10.17509/jik.v22i1.79455

No.	Author	Number of docs.	Institution/ Country	Title
				• The Validity of Mathematics Learning Model Based on Realistic Mathematics Education and Literacy in Middle School (Arnawa & Fauzan, 2023).
3	Minarni, Ani	4	University of Medan, Indonesia	• Development of Mathematics Teaching Materials Based on the Realistic Mathematics Approach (PMR) to Improve the Mathematical Reasoning…. (Aleslami et al., 2021). • Differences in Mathematical Connection Abilities and Self-Efficacy between Students Given Approaches Realistic Mathematics with the Approach Inquiry …. (Hazrati et al., 2020). • The role of constructivism-based learning in improving mathematical high order thinking skills of Indonesian students (Minarni & Napitupulu, 2020). • Differences in Increasing Students' Communication Skills and Mathematical Problem Solving through Project-Based Learning with Virtual Manipulative and Physical Manipulative Media…. (Minarni & Rajagukguk, 2021).
4	Juandi, Dadang	3	Indonesian education university	• A meta-analysis of the last two decades of realistic mathematics education approaches (Juandi et al., 2022) • The Role of Learning Media in Learning Mathematics: A Systematic Literature Review (Muhaimin & Juandi, 2023). • The Effect of Realistic Mathematics Education in Enhancing Indonesian Students' Mathematical Reasoning Ability: A Meta-Analysis (Ariati et al., 2023).
5	Rochmad, R	4	Semarang State University	• Mathematical reasoning of class VII students in terms of mathematical resilience in TAI learning with the RME approach aided by graphic organizer (Chusna et al., 2021). • Mathematical Critical Thinking Abilities of Students in Terms of Self-Regulated Learning in Realistic Mathematics Education Assisted by Mobile Learning. (Nashrullah et al., 2023). • The Effectiveness of Auditory, Intellectually and Repetitive Learning with RME Approach to Students Mathematical Communication Ability (Nisarohmah et al., 2021). • Mathematical communication ability of 7th grade Junior High School students by using Knisley's model assisted by textbook supplements (Putri & Rochmad, 2021).

Source: Google Scholar Database, 2024

Table 2 presents data on the productivity of authors in research related to the Realistic Mathematics Education (RME) approach. Five authors are active in this field, namely Prabhu R.A. from Ahmad Dahlan University, Yogyakarta, Indonesia, with four documents discussing interactive modules (Aulia & Prahmana, 2022), ethnomathematics (Prahmana & D'Ambrosio, 2020), and humanist learning models (Hendriana et al., 2022; Juniarti et al., 2022). Ahmad Fauzan from Universitas Negeri Padang, Indonesia, produced three documents on RME-based learning models that train HOTS skills (Anggraini & Fauzan, 2020), mathematical problem solving (Rahman et al., 2020), and the validity of literacy-based mathematics learning models (Arnawa & Fauzan, 2023). Ani Minarni from Medan University wrote three works, including improving mathematical connection ability (Hazrati et al., 2020), and higher-order thinking skills (Minarni & Napitupulu, 2020; Minarni & Rajagukguk, 2021). Dadang Juandi from Universitas Pendidikan Indonesia contributed three works, such as a meta-analysis of the RME approach (Juandi et al., 2022), a systematic literature review on learning media (Muhaimin & Juandi, 2023), and improving mathematical reasoning

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skills of Indonesian students (Ariati et al., 2023). Finally, Rochmad R. from Semarang State University has four documents, including studies on mathematical communication ability (Putri & Rochmad, 2021), students' mathematical resilience (Chusna et al., 2021), technology-based learning (Nashrullah et al., 2023), and the effectiveness of auditory-intellectually-repetitive learning with the RME approach (Nisarohmah et al., 2021). This data shows the significant contribution of Indonesian authors in developing RME theory and practice.

From these data, we can interpret that highly productive authors tend to focus on innovation in mathematics teaching methods, especially with the RME approach and more modern learning models such as project-based learning (PBL) (Rahman et al., 2020). The topics discussed vary, improving critical thinking and mathematical communication skills (Minarni & Napitupulu, 2020; Minarni & Rajagukguk, 2021), to the application of technology in mathematics learning (Wijaya et al., 2021). These works demonstrate efforts to improve the quality of mathematics education in Indonesia, emphasizing the importance of contextual and relevant approaches for students. This analysis shows the high productivity of authors, reflecting their involvement in developing and introducing new approaches in mathematics education and their contribution to advancing research in the field in Indonesia.

Collaborative Relationships Between Authors

The co-authorship network visualization generated using VOSviewer provides in-depth insights into the collaborative relationships between authors in research related to Realistic Mathematics Education (RME) and self-confidence in mathematics education curriculum. Each node in this network represents an author, while the lines connecting the nodes indicate the presence of collaboration between authors in one or more articles (Xiao et al., 2022). The node's size reflects the authors' productivity based on the number of documents they produce. At the same time, the thickness of the line indicates the intensity of collaboration between authors (Donthu et al., 2021).

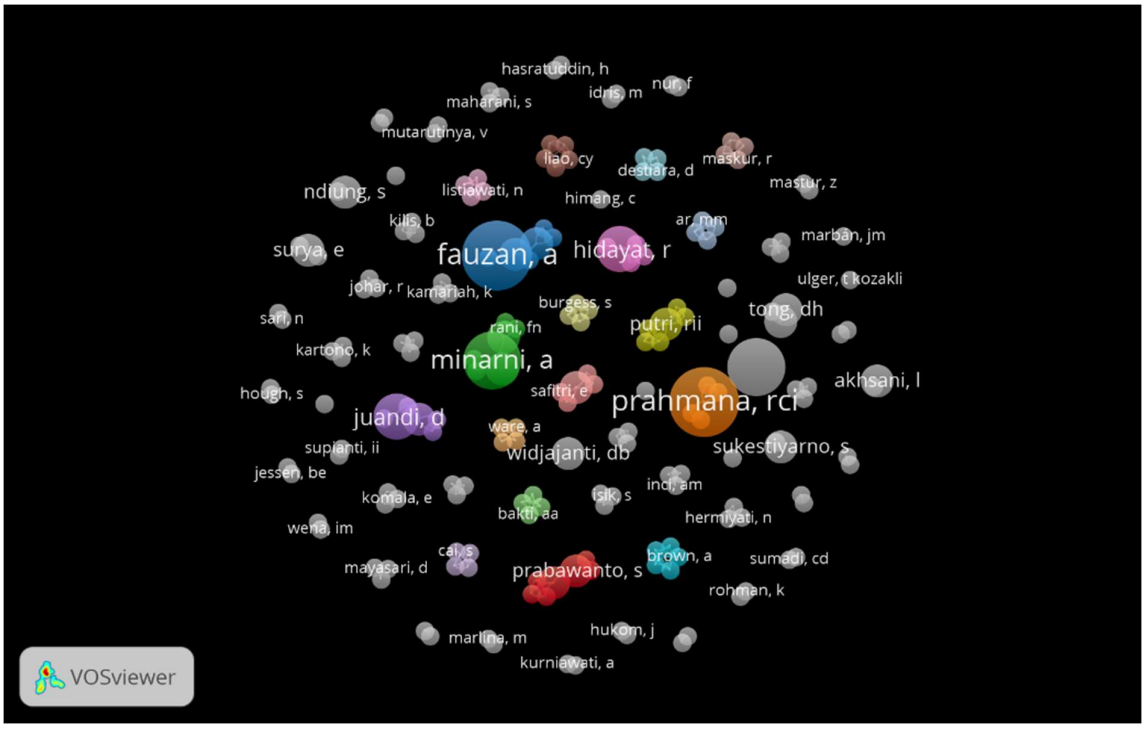

Figure 1. Visualization of Co-Authorship Network Analysis on Research Related to RME, Self-Confidence, and Mathematics Education Curriculum
Source: VOSviewer, 2024

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A co-authorship network analysis visualization image was generated using VOSviewer software based on **Figure 1**. This analysis shows the network of authors' collaboration based on the number of joint publications. Nodes in the image represent authors, with the node's size reflecting their level of contribution or influence in the network, such as the number of publications or the frequency of collaboration. The relationship between nodes is shown by lines indicating the collaboration between two authors, while the node's color marks the cluster or subgroup of collaborations formed. Large nodes, such as Fauzan, A., Prahmana, RCI., Minarni, A., and Juandi, D., indicate that they are the central figures with high levels of collaboration, playing a significant role in this research network. Meanwhile, small nodes indicate authors with more limited contributions or involvement in fewer collaborations (Akbaş & Yıldırım, 2024; Ulger et al., 2022)

Interpretation of this visualization shows the presence of several separate collaboration clusters, indicating subgroups of authors who have a particular research focus or work together in a smaller community. Clusters dominated by Fauzan, A., and Prahmana, RCI. They tend to be centralized, indicating they are leaders or key liaisons in research in a particular field. In contrast, smaller clusters, such as those involving Prabawanto, S. or Putri, RI. Indicate that their contributions, although important, are less widely connected than the central cluster (Rahayu et al., 2022; Siregar et al., 2023; Wardani et al., 2024).

From this analysis, it can be concluded that the collaboration network in the analyzed research is centered on several primary authors, such as Fauzan, A. and Prahmana, RCI., who play a significant role in uniting researchers from various clusters. However, separate clusters indicate the potential for increased collaboration between researchers across clusters. Efforts to bridge separate clusters can increase connectivity and expand the collaboration network, thus allowing for a broader exchange of ideas and more significant research developments.

This visualization shows that Realistic Mathematics Education research has a reasonably segmented collaboration network, with a few key authors as the main hubs. These authors play a significant role in strengthening the relationships between authors and facilitating the exchange of ideas and research across groups. This structure shows a healthy collaboration dynamic, where research is conducted collectively through active author interaction.

The Development of Collaboration Between Writers Over Time

This visualization of co-authorship overlay analysis generated using VOSviewer provides an overview of the development of collaboration between authors over time in research related to Realistic Mathematics Education (RME). The colors on the nodes represent the period of the author's contributions to the publications, as shown in the color scale at the bottom of the figure. Blue indicates publications made at the beginning of the period (2020), while yellow indicates more recent publications (2024).

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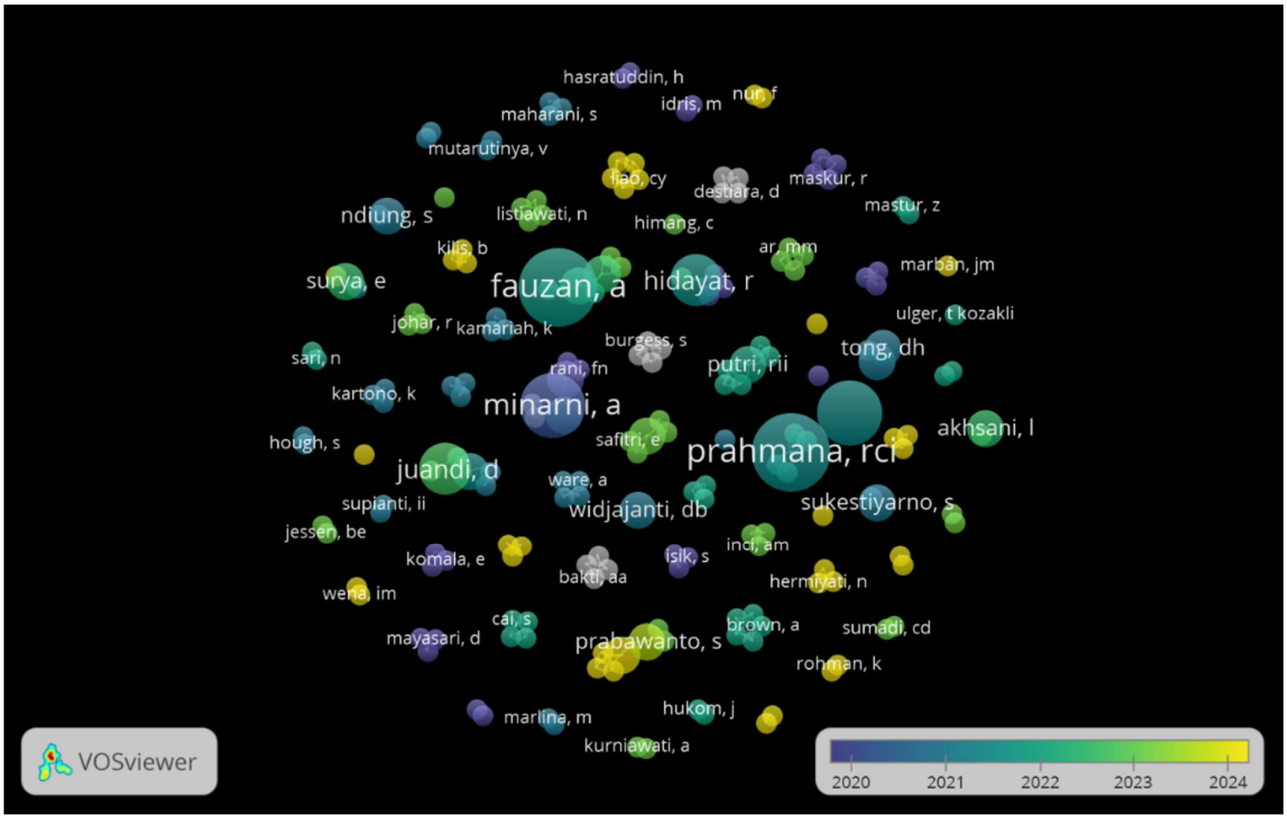

Figure 2. Visualization of Co-Authorship Overlay Analysis on Research Related to RME, Self-Confidence, and Mathematics Education Curriculum
Source: VOSviewer, 2024

In **Figure 2**, node size represents the level of contribution or influence of the author, while the lines connecting the nodes indicate their collaboration. Large nodes such as Fauzan, A., Prahmana, RCI., and Minarni, A. remain prominent, indicating their roles as primary authors with significant levels of collaboration (Anggraini & Fauzan, 2020; Aulia & Prahmana, 2022; Hazrati et al., 2020; Hendriana et al., 2022; Juniarti et al., 2022). Nodes with a yellower color, such as several nodes around Prabawanto, S., reflect more active authors in current research (Siregar et al., 2023; Wardani et al., 2024).

The interpretation of this visualization shows that research collaborations have continued to grow during the analyzed period. Yellow nodes indicate increased research activity, reflecting the relevance and new contributions to the network. Prahmana, RCI., for example, remains one of the main links in this network, with activities that continue to the present (Aulia & Prahmana, 2022; Hendriana et al., 2022; Juniarti et al., 2022). In contrast, blue or green nodes, such as those of Ndiung, S. and Mutarutinya, V., indicate that their research is in the previous period, and their collaboration may have declined or stabilized. Furthermore, the color distribution indicates a diversification in the research cluster, with new subgroups emerging in the present period (Mukuka et al., 2021; Ndiung et al., 2021).

In conclusion, this overlay analysis shows that the author's collaboration network has developed dynamically over time. The role of primary authors, such as Fauzan, A., Prahmana, RCI., and Minarni, A., remains significant, while several new authors have begun to be actively involved in current research. This finding provides an opportunity to strengthen cross-cluster collaboration by involving researchers who have been active recently so that this network can continue to grow and produce broader contributions in the future.

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In addition, this overlay visualization provides a rich temporal picture of how collaborations between authors have evolved. This helps identify collaboration trends and provides opportunities to integrate new researchers into the broader network. These dynamics demonstrate the importance of building inclusive and sustainable networks in supporting the development of research in Realistic Mathematics Education.

Density of Collaboration Between Authors

The image is a visualization of this study's co-authorship density analysis, which shows the collaboration density between authors based on bibliometric data. This visualization uses a color gradient, where yellow indicates areas with high collaboration density, while green and blue indicate lower densities. Lighter nodes indicate authors who are more frequently involved in collaboration or have a broad collaboration network.

Large nodes such as Fauzan, A., Minarni, A., Prahmana, RCI., and Juandi, D., are seen in bright yellow, indicating their dominant role in this collaboration network. These nodes are located in the center of the high-density area, indicating that they are the leading figures and drivers in research related to Realistic Mathematics Education (RME). Their roles as authors with high levels of collaboration indicate significant contributions to this network.

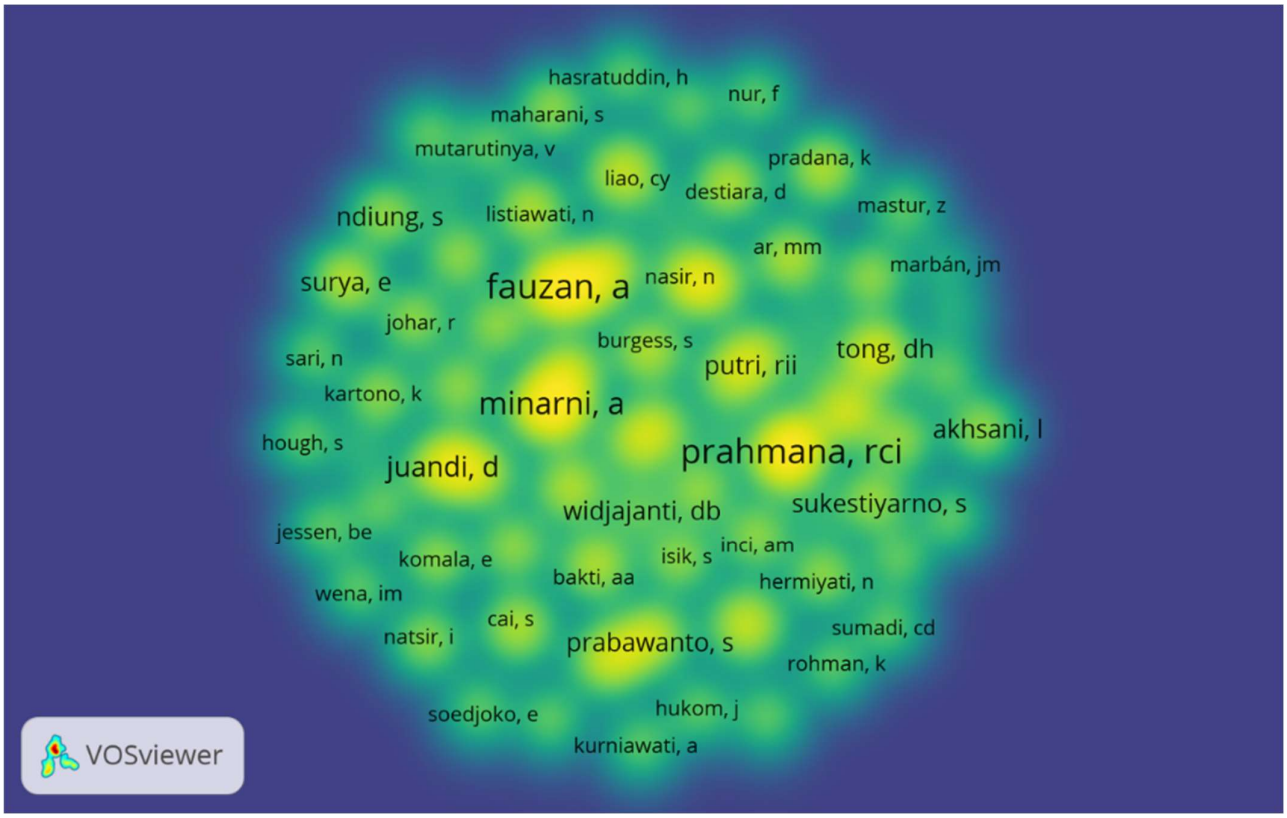

Figure 3. Visualization of Co-Authorship Density Analysis on Research Related to RME, Self-Confidence, and Mathematics Education Curriculum
Source: VOSviewer, 2024

In **Figure 3**, the color intensity indicates the level of collaboration between authors, where yellow indicates high collaboration density, green indicates medium density, and blue or purple indicates low density. Authors such as Fauzan, A., Prahmana, RCI., Marni, A., and Juandi, D. are in the center with a bright yellow color, indicating that they are the main actors in this collaboration network. On the other hand,

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names on the periphery, such as Nafsuuddin, H., and Komala, E., are in greener or bluer areas, indicating smaller collaboration contributions (Rani et al., 2020).

In terms of patterns, this collaboration network has a structure centered on several primary authors. Fauzan, A., for example, stands out as a center of collaboration with extensive connections to many other authors. The same is true for Prahmana, RCI., one of this network's central figures. In contrast, authors in the peripheral areas of the network tend to have fewer connections and limited collaboration. The green color spreading towards the periphery shows that although this network is expanding, the intensity of collaboration decreases with increasing distance from the main center of collaboration. Authors such as Surya, E., Ndiung, S., and Widjajanti, DB. have contributed, although not as intensively as the primary author. They may collaborate on specific projects or as partners in smaller collaboration circles (Fitria et al., 2021; Hutasuhut et al., 2024; Ndiung et al., 2021).

This visual interpretation provides insight into how collaboration in research networks occurs. Authors with high yellow intensity tend to be key connectors that expand collaboration across the network. They may be more productive in publishing or more active in collaborating with other authors. In contrast, authors in green and blue areas tend to have less influence, either because they are involved in fewer collaborations or because they focus on collaborating with a small group of authors.

Based on this analysis, it can be concluded that this collaboration network has a clear structure with several central actors driving scientific collaboration, such as Fauzan, A., Prahmana, RCI., and Minarni, A. This pattern shows that a central figure is essential to connecting various researchers in the network and encouraging research productivity. However, a strategy needs to be developed to encourage more equitable collaboration, especially by involving authors on the network's periphery so that their contributions can be further optimized in future scientific collaborations.

Relationship Between Keywords Based on Frequency of Co-Occurrence

The co-occurrence network analysis visualization illustrates the relationship between terms or keywords often appearing in research related to Realistic Mathematics Education (RME). Each node in this visualization represents a keyword. In contrast, the lines connecting the nodes reflect the relationship or association between the keywords based on the frequency of their co-occurrence in publications. There are five clusters, among others:

Cluster 1: application, elementary school, impact, Indonesia, interest, mathematics education, realistic mathematics education, research, role, term, theory.

Cluster 2: achievement, attitude, concept, effect, implementation, model, motivation, outcome, self-confidence, students self-confidence

Cluster 3: ability, analysis, development, independence, influence, realistic mathematics education, self-efficacy, understanding.

Cluster 4: confidence, lack, mathematical concept, school, self, self-confidence, teacher.

Cluster 5: approach, junior high school student, rme, rme approach.

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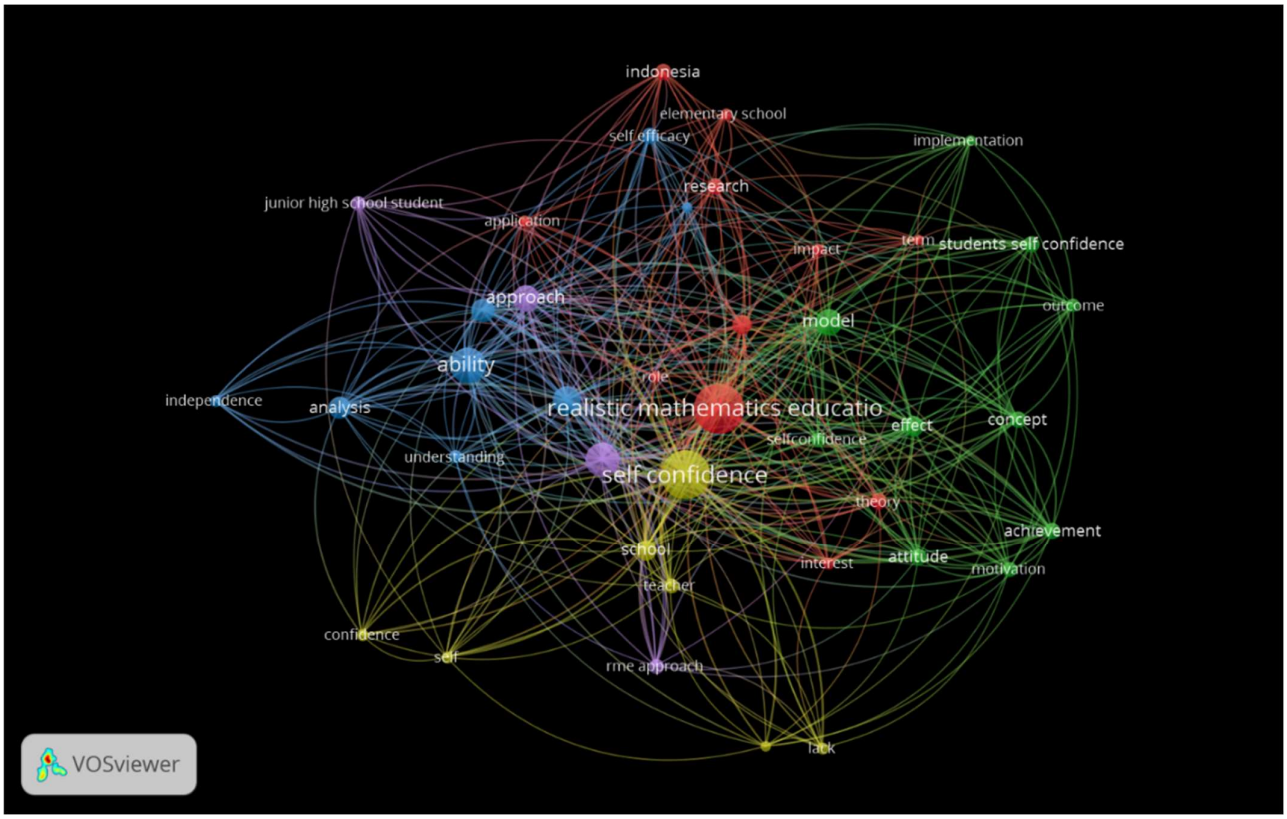

Figure 4. Visualization of Co-Occurrence Network Analysis on Research Related to RME, Self-Confidence, and Mathematics Education Curriculum
Source: VOSviewer, 2024

In **Figure 4**, nodes with larger sizes, such as realistic mathematics education, self-confidence, and ability, show the main keywords that appear most frequently in this study. This indicates that themes such as the RME approach, developing self-confidence, and student abilities are the main focus of related studies (Anggraini & Fauzan, 2020).

The colors of the nodes and lines reflect different clusters or thematic groups. Five colors represent each cluster.

1. The red cluster in **Figure 5** focuses on implementing the Realistic Mathematics Education (RME) approach in elementary school environments, especially in Indonesia. Keywords such as application, elementary school, and realistic mathematics education indicate attention to how this approach is applied in mathematics learning in elementary schools (Kusmaryono & Maharani, 2021; Samura & Siagian, 2023; Sucahyo et al., 2021). In this cluster, issues such as student interest, teacher role, and theories underlying the implementation of RME are explored. The main focus is how RME can improve the quality of mathematics learning by considering the local context and students' needs (Amany et al., 2023; Nguyen & Pham, 2023).

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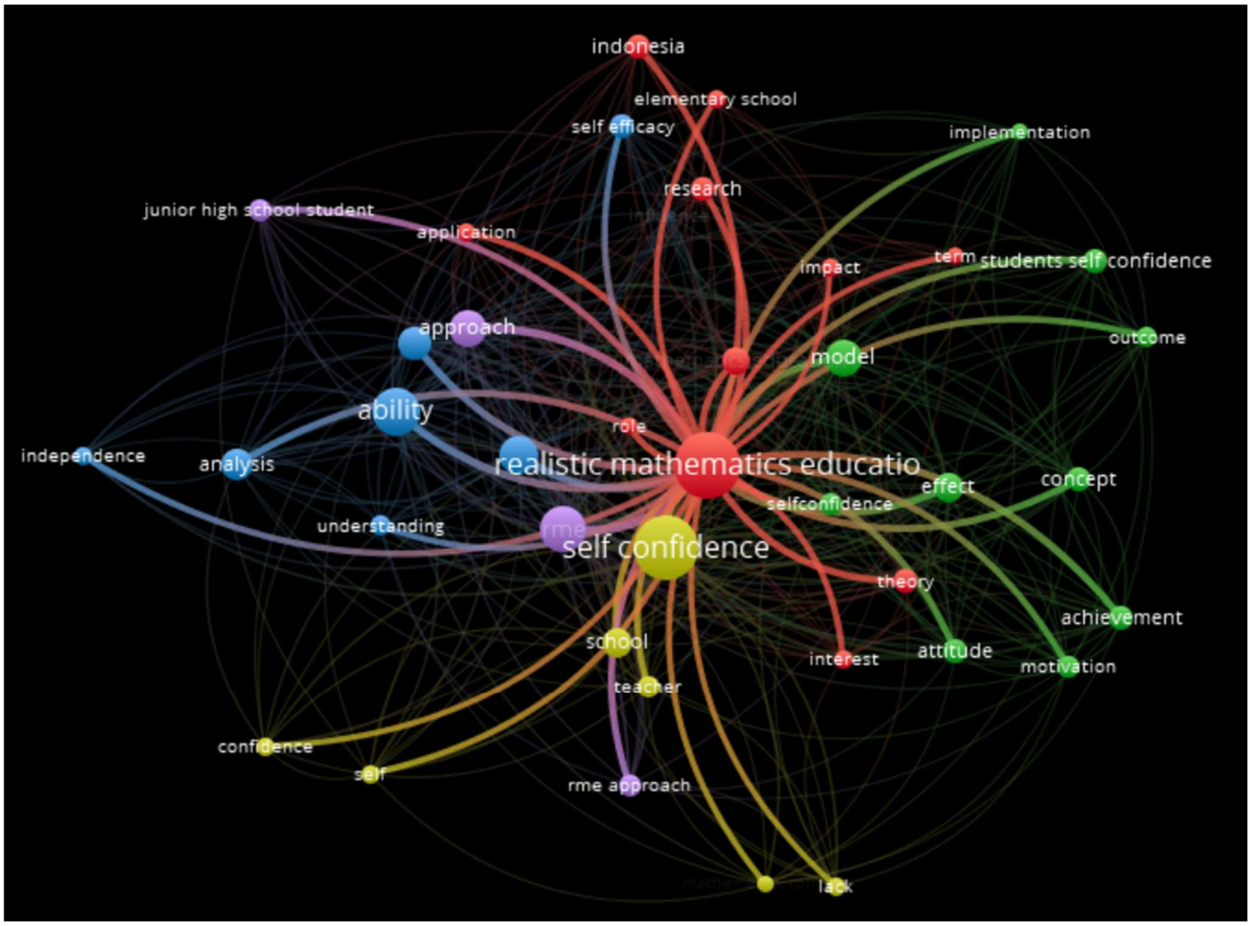

Figure 5. Visualization of Co-Occurrence Network Analysis in The Red Cluster
Source: VOSviewer, 2024

2. The green cluster in **Figure 6** highlights the relationship between motivation, self-confidence, and student learning outcomes in mathematics. Keywords such as achievement, self-confidence, and student self-confidence indicate the importance of building student self-confidence in learning (Psaras et al., 2020). This cluster also discusses how implementing specific learning models affects students' academic achievement. In addition, concepts such as motivation, outcome, and implementation are the focus of understanding how learning strategies can be optimized to improve the success of student learning outcomes (Ajid & Sholeh, 2021; Ndiung et al., 2021; Ridwan et al., 2024).

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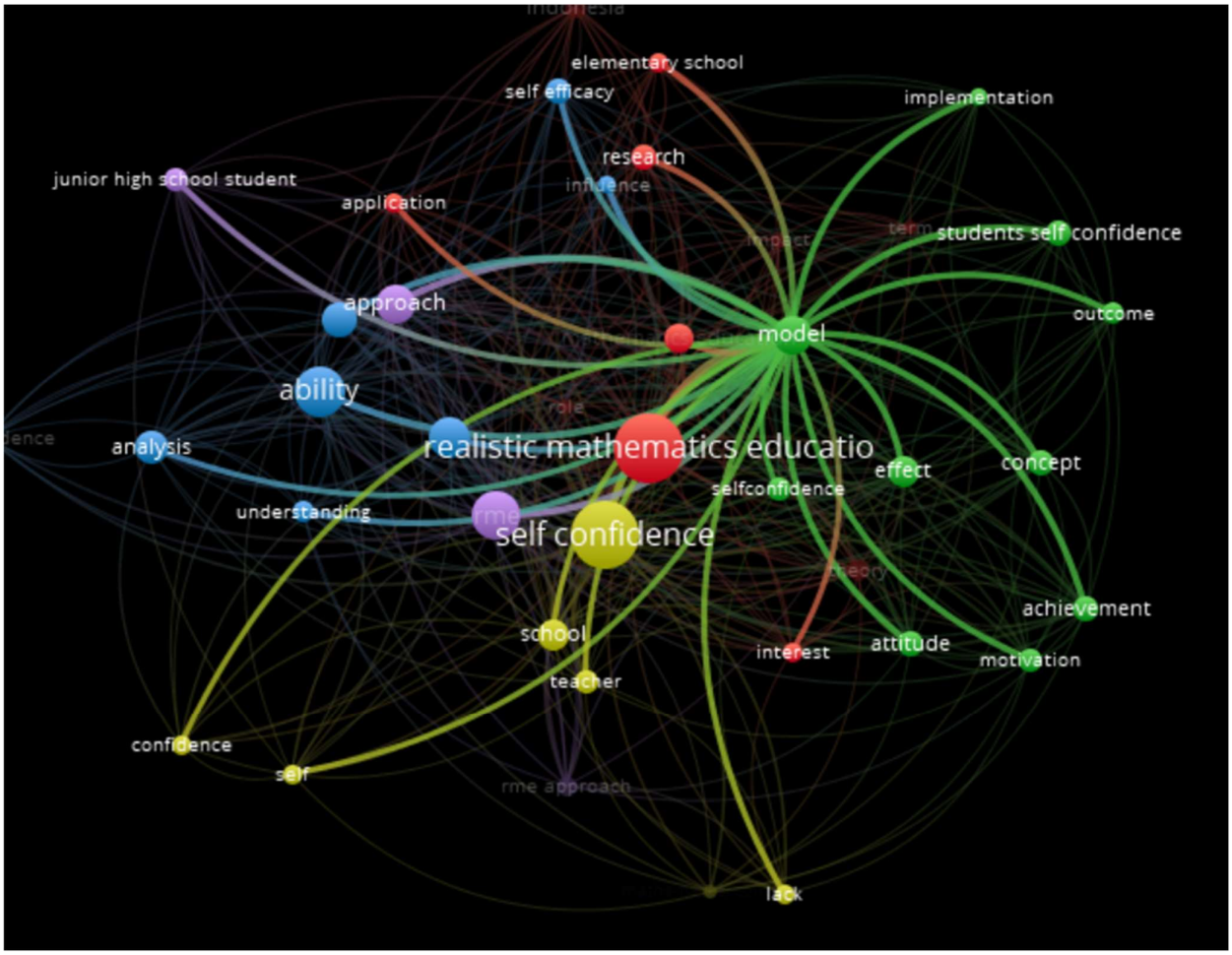

Figure 6. Visualization of Co-Occurrence Network Analysis in The Green Cluster
Source: VOSviewer, 2024

3. The blue cluster in **Figure 7** is closely related to developing students' abilities in understanding mathematics through an approach that supports self-efficacy and independence. Keywords such as ability, understanding, and development show attention to students' analytical abilities and in-depth understanding of mathematics learning. This cluster also emphasizes the importance of the influence of learning approaches on students' self-confidence in independently solving problems integrated into the curriculum (Maskur et al., 2020; Mirtasari, 2024). The main focus is how RME-based learning can encourage students to develop independence in thinking and learning (Anggraini & Fauzan, 2020; Hazrati et al., 2020; Muhtadi et al., 2022).

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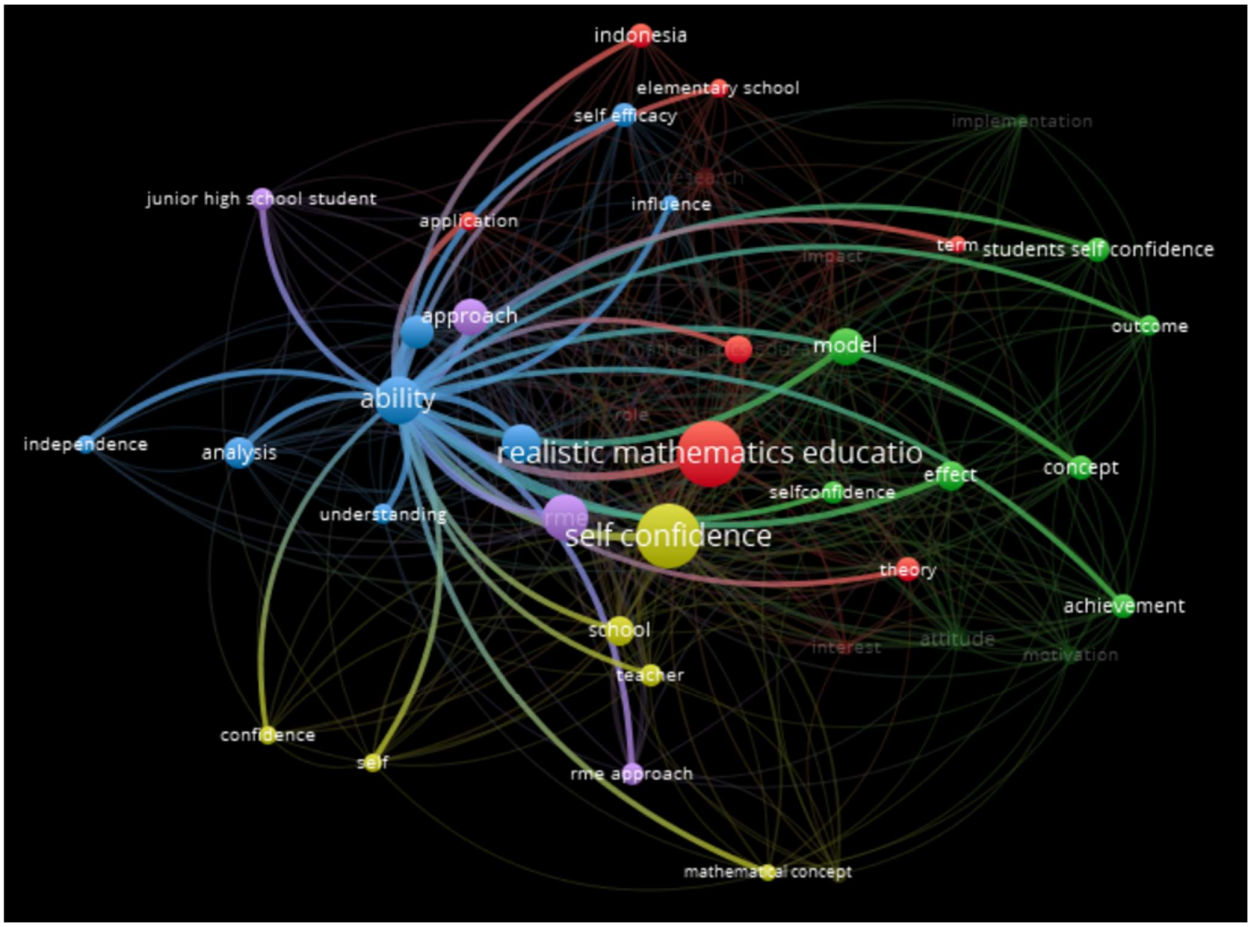

Figure 7. Visualization of Co-Occurrence Network Analysis in The Blue Cluster
Source: VOSviewer, 2024

4. The yellow cluster in **Figure 8** emphasizes the critical role of teachers in building students' self-confidence during the mathematics learning process. Keywords such as confidence, self-confidence, and teacher indicate that teachers create a learning environment that effectively supports mathematical concept development (Dahlan et al., 2024; Nguyen & Pham, 2023). In addition, this cluster also discusses the role of schools as a place to strengthen students' self-confidence, especially in understanding and applying mathematical concepts (Sucahyo et al., 2021).

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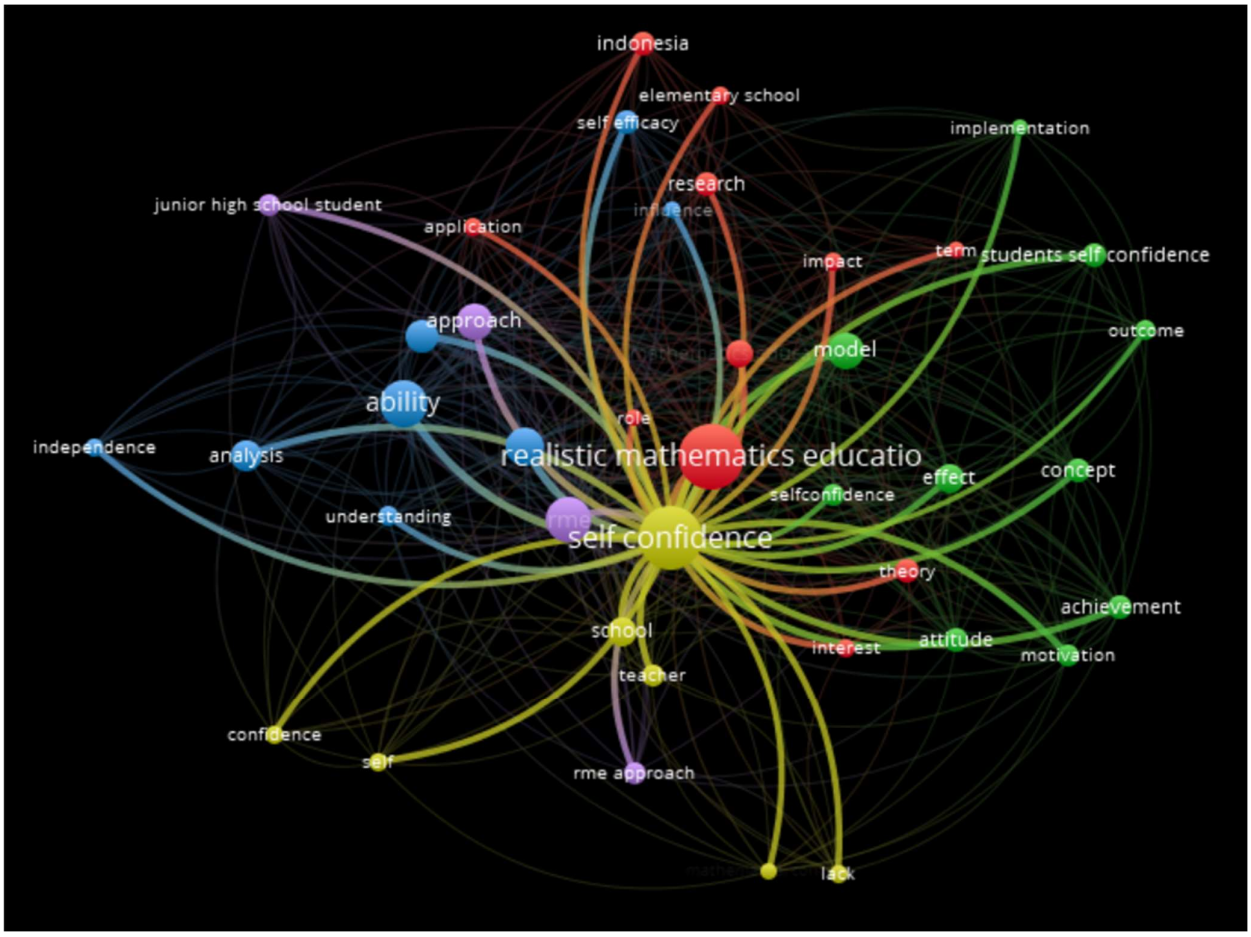

Figure 8. Visualization of Co-Occurrence Network Analysis in The Yellow Cluster
Source: VOSviewer, 2024

5. This purple cluster in **Figure 9** focuses on implementing the RME approach at the junior high school level. Keywords such as approach, junior high school student, and RME indicate attention to the effectiveness of learning strategies used for junior high school students. The RME approach in this cluster is explored in a broader context, including how this strategy helps students understand mathematics contextually and relevantly to their daily lives (Anggraini & Fauzan, 2020; Aulia & Prahmana, 2022; Juandi et al., 2022). This cluster emphasizes the importance of a real-world problem-based learning approach to increase students' interest and understanding and is integrated into the Mathematics Education curriculum (Caraan et al., 2023; Hazrati et al., 2020; Maskur et al., 2020).

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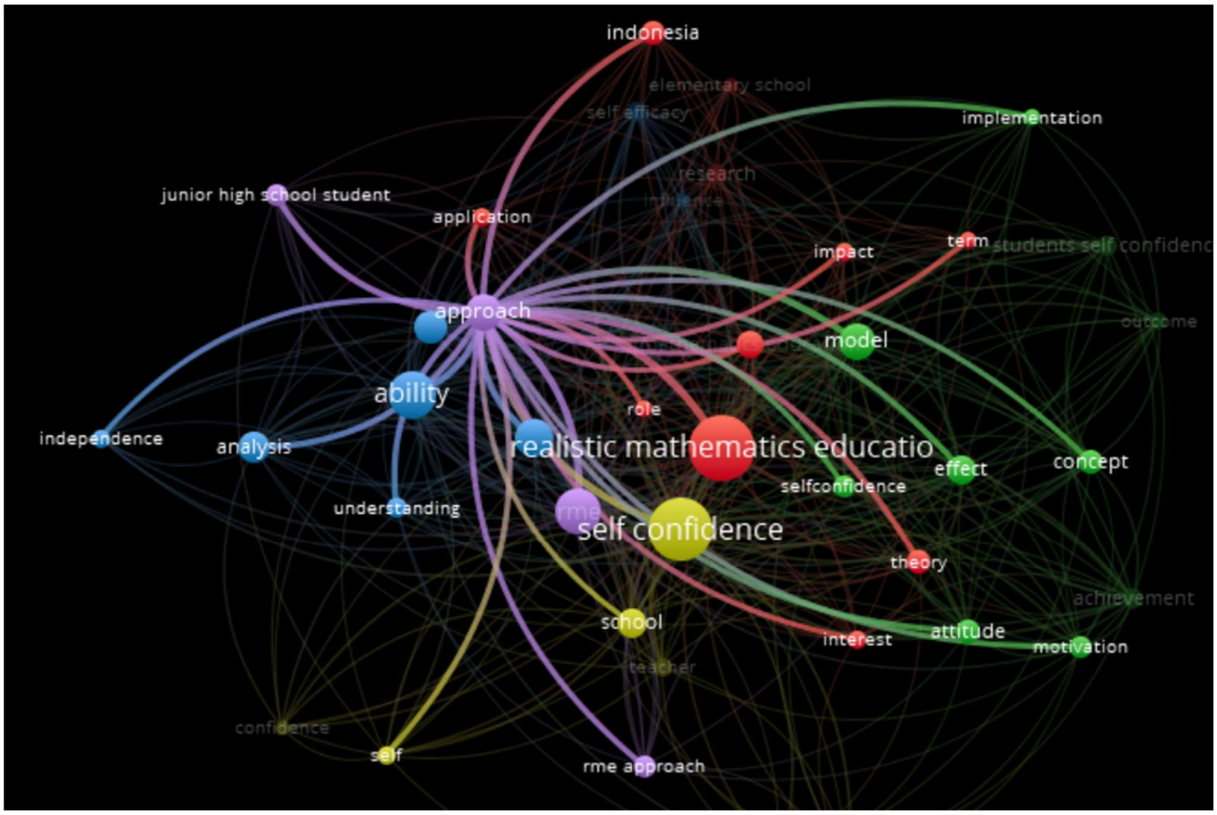

Figure 9. Visualization of Co-Occurrence Network Analysis in The Purple Cluster
Source: VOSviewer, 2024

This analysis provides in-depth insights into the conceptual structure of RME-related research. By understanding the clusters and relationships between keywords, researchers can identify dominant themes and potential research gaps for further exploration. For example, weaker relationships between specific nodes may indicate the need to explore further aspects that have received less attention, such as the relationship between motivation and implementation. This visualization reflects the diversity of topics discussed in RME research and the importance of synergy between themes to build a more comprehensive understanding. The results of this analysis can serve as a guide to direct research in a more in-depth and collaborative direction in the future.

Research Trends and Developments on RME and Self-Confidence

The co-occurrence overlay analysis visualization illustrates the relationship between keywords in research on Realistic Mathematics Education (RME) and its influence on self-confidence in mathematics education curriculum. This visualization displays the relationship between keywords and shows how research trends develop over time. The visible color gradient, from blue to yellow, reflects the chronology of keyword emergence in research, where blue indicates earlier research (around 2021), green represents the middle period (2022), and yellow indicates keywords that appear in the latest research (2023).

Based on **Figure 10** the dominant keywords are realistic mathematics education and self-confidence, which shows that the main focus of the study is how the contextually relevant RME approach affects students' self-confidence in learning mathematics. This keyword is the center of the visualization, with many connections to other terms such as ability, achievement, and student self-confidence. This

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relationship illustrates that the learning approach aims to improve academic outcomes and develop students' affective aspects (Anggraini & Fauzan, 2020).

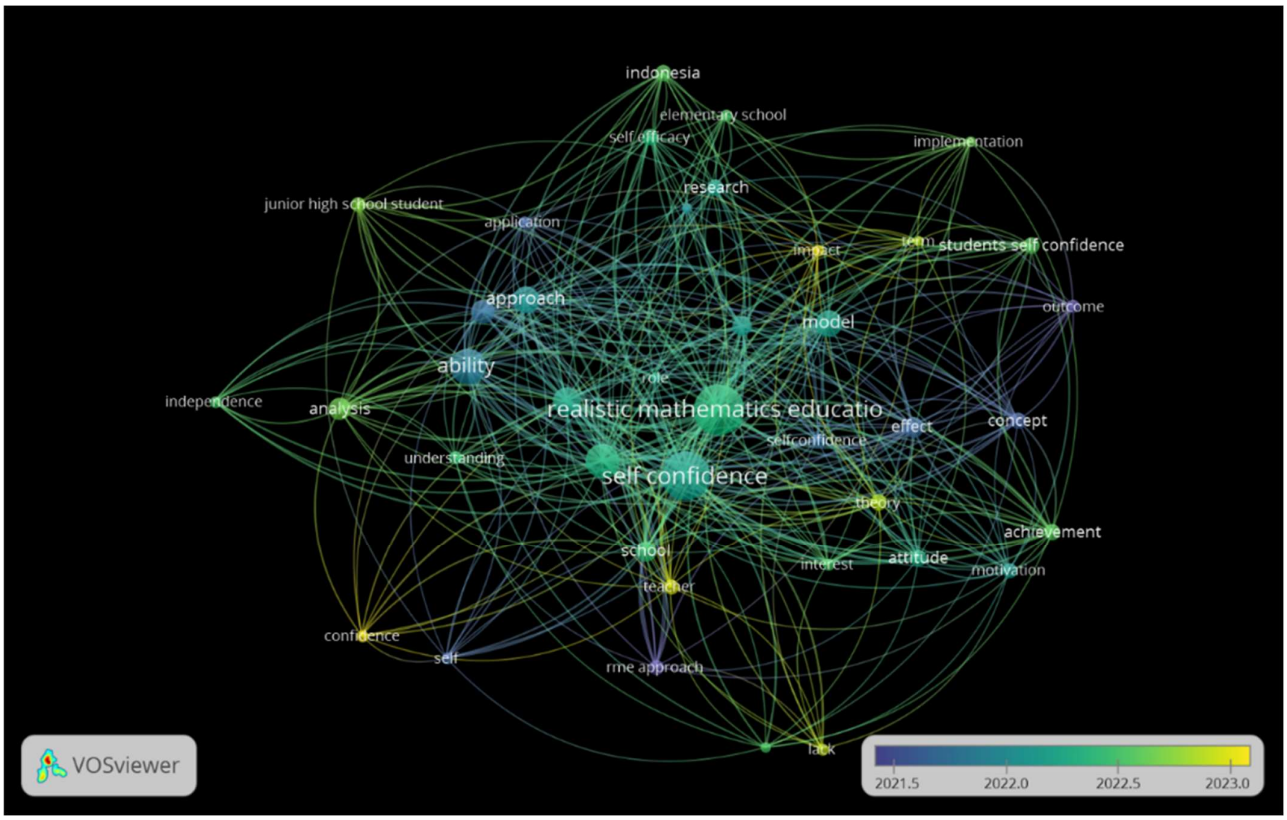

Figure 10. Visualization of Co-Occurrence Overlay Analysis on Research Related to RME, Self-Confidence, and Mathematics Education Curriculum
Source: VOSviewer, 2024

The research context is seen from keywords such as Indonesia, elementary school, and junior high school student, which show that this research is primarily conducted in the context of education in Indonesia, especially at the elementary and junior high school levels (Kusmaryono & Maharani, 2021; Mirtasari, 2024; Samura & Siagian, 2023; Sucahyo et al., 2021). Terms such as model, application, and implementation indicate a focus on how the RME approach integrated into the Mathematics Education curriculum is practically applied in the classroom, while keywords such as motivation, confidence, and independence indicate the psychological impacts that are the primary concern in this approach (Anggraini & Fauzan, 2020; Aulia & Prahmana, 2022; Juandi et al., 2022; Maskur et al., 2020; Sucahyo et al., 2021)

In the early stages of research in 2021, the main focus of this research is to explore the basics of the Realistic Mathematics Education (RME) approach. The research focused on understanding the concept, the relevance of the theory, and the role of RME in the mathematics curriculum and learning. Keywords such as theory, role, and impact in the blue area indicate that the research seeks to strengthen the theoretical foundation. In this phase, the researchers highlighted the importance of a contextual approach to connecting the mathematics curriculum and learning with real experiences (Maskur et al., 2020) while considering how the role of RME can help students understand the material more deeply. This initial focus lays an essential foundation for further, more applied research (Anggraini & Fauzan, 2020; Minarni & Napitupulu, 2020).

Entering 2022, research shifted from theoretical exploration to actual implementation in learning contexts. The dominance of keywords such as implementation, model, and application in the green area reflects the

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increasing attention to the practical application of the RME approach in the classroom. Research in this phase also explores the impact of this approach on student learning outcomes (outcomes) and its influence on affective aspects such as self-confidence. Researchers focus on how the RME model can be effectively integrated into the curriculum and on factors that influence the success of its implementation, including teacher support and learning structure (Ndiung et al., 2021).

In recent years, in 2023, research has shown a significant shift towards the long-term outcomes and psychological impact of the RME approach. The yellow area highlights keywords such as student's self-confidence, achievement, and effect, which have been of significant interest in recent research. Recent research focuses on how RME improves students' mathematical abilities and builds their confidence in facing academic challenges (Samura & Siagian, 2023). In addition, the emergence of keywords such as self-efficacy highlights a more profound psychological dimension, namely how students feel capable and confident in using their mathematical skills in real-life situations (Berlian et al., 2023). This research emphasizes the importance of the influence of the RME approach in preparing students holistically, both in cognitive and affective aspects (Ahmad et al., 2023).

The research developments from 2021 to 2023 show a clear evolution from theory to practice and ultimately to long-term impact. This trend reflects how the RME approach is increasingly accepted as an effective method for improving mathematics learning outcomes and building the foundations of students' self-confidence and psychological abilities. In this context, future research will likely continue to explore how this approach can be extended and adapted to different contexts and levels of education to have a broader impact on student learning outcomes. This analysis also shows the importance of integrating contextual approaches such as RME with strategies that support students' psychological development.

Keyword Density Appears Together

The co-occurrence density analysis of the research entitled "Bibliometric Analysis: Trends in RME Research and Its Influence on Self-Confidence in Mathematics Education Curriculum" illustrates a concept map based on the relationship between keywords in the literature. In this visualization, areas with yellow to green color density indicate keywords that often appear together and have a high level of relevance in the research. Meanwhile, the blue area indicates concepts with lower relevance but still have a relationship in the overall context.

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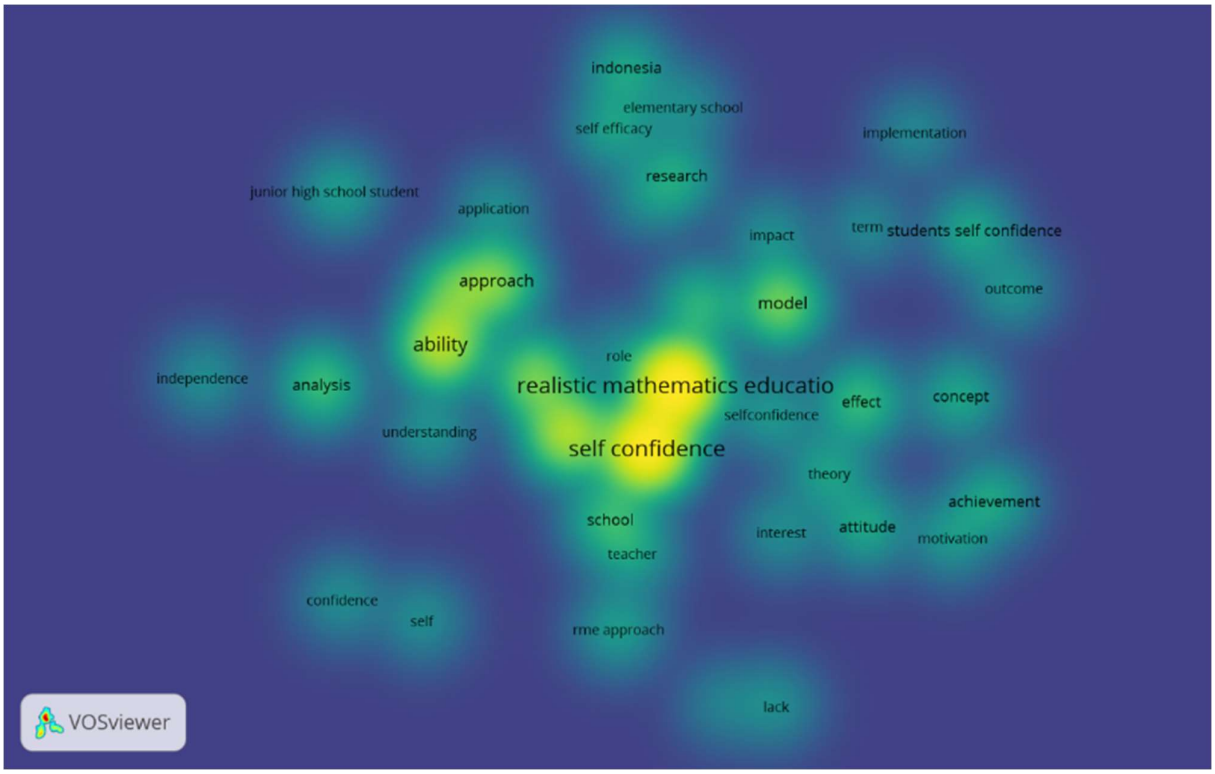

Figure 11. Visualization of Co-Occurrence Density Analysis on Research Related to RME, Self-Confidence, and Mathematics Education Curriculum
Source: VOSviewer, 2024

This keyword co-occurrence density map illustrates the research focus on Realistic Mathematics Education (RME) and its impact on students' self-confidence based in **Figure 11**. The bright yellow areas indicate keywords with high density, such as realistic mathematics education and self-confidence, which are the core of this study. This shows that most studies focus on how the RME approach can be applied to improve students' self-confidence in mathematics learning. In addition, the keyword ability also appears in the same area, emphasizing the relevance of mathematics ability as an essential aspect related to students' self-confidence.

The green-blue area has keywords such as independence, analysis, and understanding. Although not as dense as the core keywords, these terms are still an essential part of the research ecosystem, indicating attention to more profound learning outcomes and the development of students' critical and creative thinking skills in the curriculum (Maskur et al., 2020; Muhtadi et al., 2022; Rani et al., 2020). Furthermore, keywords such as interest, motivation, and attitude are also spread in this area, reflecting the research focus on affective aspects that support the success of RME implementation, such as increasing students' interest in learning and motivation (Amany et al., 2023).

In addition, keywords such as implementation, model, and application indicate that the study also highlights the practical application of the RME approach. The placement of these keywords indicates an exploration of how RME can be applied effectively to achieve optimal learning outcomes (Ndiung et al., 2021; Ridwan et al., 2024). Thus, this map visualizes the main research trends and illustrates the distribution of attention to various aspects, from practical applications to psychological impacts on students. Future research can explore more deeply how RME can be adapted to various cultural contexts and educational levels and how other affective aspects, such as intrinsic motivation, can be strengthened through this approach. This visualization provides valuable guidance for researchers to understand the trends and directions of development in this field.

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The interconnectedness of the discussions in this study can be seen from how each aspect, from the application of Realistic Mathematics Education (RME) and its influence on students' self-confidence to its impact on mathematics learning outcomes, is interconnected within the framework of the mathematics education curriculum. The bibliometric analysis shows that the RME approach improves the understanding of mathematical concepts and builds students' confidence significantly through contextualized learning strategies relevant to real life. The significant impact of this research lies in its role in encouraging collaboration across researchers and the development of theory to practice, which has proven effective in improving students' cognitive and affective learning outcomes at various levels of education, especially in the Indonesian context.

Based on the research results, the Realistic Mathematics Education (RME) approach significantly improved students' confidence and mathematical abilities. Bibliometric analysis shows that research on this topic has received widespread attention in the academic community, with high citation rates and significant contributions to mathematics education curriculum development. The RME approach links mathematics learning to real contexts and can improve students' concept understanding, creative thinking skills, and problem-solving abilities. In addition, this study also showed a high level of collaboration between researchers, which plays an essential role in expanding the scope and impact of research in this area.

Furthermore, the analysis shows that the implementation of RME benefits cognitive aspects and supports the development of students' affective aspects, such as self-confidence and motivation to learn. This finding is reinforced by bibliometric data that shows the consistency of researchers' contributions in this field, with publications of high quality and broad relevance. In addition, the pattern of collaboration between authors shows a strong and dynamic research network, enabling the exchange of ideas and the development of innovations in mathematics education. The conclusion of this study confirms that RME is a practical and relevant approach in supporting more inclusive, contextualized, and student needs-based mathematics learning.

CONCLUSION

The bibliometric analysis shows that research on Realistic Mathematics Education (RME) and its influence on students' self-confidence in the mathematics education curriculum has grown significantly during 2020-2024. With a total of 200 articles analyzed and more than 2,300 citations, this topic has become the focus of attention of the scientific community. The high average citations per article and per author indicate its significant relevance and influence in the mathematics education literature. Collaboration between authors shown by the co-authorship network visualization reveals that several primary authors act as key links in the research network, such as Fauzan, A and Prahmana, RCI. This centralized collaboration structure has contributed significantly to the development of the RME approach, although further efforts are needed to bridge separate clusters to expand connectivity and synergy across groups. In terms of themes, the co-occurrence analysis shows that the main focus of the study is how the RME approach can improve students' self-confidence and mathematical abilities. This study highlights the relevance of the RME approach in building students' cognitive and affective skills, with special attention to practical implementation and psychological impacts in mathematics learning.

Research trends evolve from theoretical exploration to practical implementation and long-term impact. In recent years, research has focused more on integrating RME into the curriculum and how this approach can holistically build students' self-confidence. Thus, RME is considered effective in improving students' academic abilities and supporting psychological development, which is essential for future learning success. The results of this analysis underscore the importance of broader and deeper collaboration between researchers and the integration of the RME approach with contextual and innovative learning

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strategies. Future research could extend this approach to a broader range of educational levels and explore how other affective aspects, such as intrinsic motivation, can be strengthened by implementing RME.

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