

A bibliometric analysis of realistic mathematics education research (2000-2025): Global trends and development

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ABSTRACT

This study presents a comprehensive bibliometric analysis of realistic mathematics education (RME) research from 2000 to 2025, focusing on global trends and development. Employing VOSviewer and CiteSpace, we analyzed a dataset of publications related to RME. Our analysis explores key themes, influential authors, prominent countries, and the evolution of research topics within the RME field. The findings reveal significant growth in RME research globally, with a shift towards diverse applications and adaptations of the RME approach. We identify influential clusters of research focusing on areas such as curriculum development, teacher education, technology integration, and specific mathematical domains like geometry and algebra. The study also highlights the emergence of new research areas, including the integration of digital tools and the exploration of RME's impact on diverse learner populations. Furthermore, we examine the collaborative networks between researchers and institutions, identifying key players and collaborative patterns across different countries. This analysis provides valuable insights for researchers, educators, and policymakers interested in understanding the current state and future directions of RME research, ultimately contributing to the advancement of mathematics education globally.

Keywords: realistic mathematics education, mathematics education, bibliometric analysis, global trends, development trends

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INTRODUCTION

Many researchers have suggested that the primary goal of school mathematics education is to prioritize the development of students' mathematical abilities (Susanta et al., 2023). Listiawati et al. (2023) have shown that there are many teaching methods that have the potential to improve students' mathematical skills, including the realistic mathematics education (RME) method.

RME is known as an instructional theory developed in mathematics education. RME is derived from Freudenthal's (1973, 1991) idea of "mathematics as a human activity". He also emphasized the actions and activities of mathematical thinking, rather than the final result, thereby forming the view of mathematics learning as a process of "progressive mathematization". Lady et al. (2018) said that RME is a form of learning designed based on the reality and environment around students, to help students explore mathematical

concepts in a natural context that they have not previously learned. Also from this point of view, other researchers believe that the RME method starts from the reality and experiences of learners, through which mathematical concepts or mathematical knowledge are built through solving problems arising from reality (Dewantara et al., 2023; Diponegoro et al., 2024; Van Zanten & Van den Heuvel-Panhuizen, 2021).

Çilingir Altın (2021) emphasized that the introduction of RME not only connects mathematical concepts with real-world applications but also creates an environment where mathematical understanding becomes truly meaningful to students. According to Treffers' (1993) research, RME integrates both horizontal and vertical mathematization processes. As a result, RME makes mathematics accessible, understandable, and highly practical for learners (Bray & Tangney, 2015). A study by Şengül et al. (2017) on improving measurement estimation skills showed that RME-based teaching methods are more effective than traditional

methods. This finding highlights the practical application and effectiveness of integrating RME principles in training students' measurement estimation skills.

Over time, RME has gradually affirmed itself as a positive approach to teaching, which takes the practice and real-life experiences of learners in daily life as the starting point and turns mathematics into a learning activity for learners (Laurens et al., 2018). Research by Palinussa et al. (2025) has shown that the RME method has gradually had a certain influence on the development of mathematics learning worldwide over time. In the same study, RME was emphasized as a method to support improving teaching quality and learning effectiveness (Palinussa et al., 2025). In addition, many studies have shown the outstanding advantages of the RME method such as contributing to making mathematics learning more meaningful, less formal, less abstract and more interesting (Bosica et al., 2021; Fauzan et al., 2024).

Also in this view, the RME method has many benefits such as making mathematics learning more meaningful, less formal, and more approachable and engaging (Bosica et al., 2021; Fauzan et al., 2024). RME is designed based on the reality and environment around students to help students explore mathematical concepts in natural contexts that they have not learned before (Lady et al., 2018). Some studies agree that in RME, the reality and experience of learners are placed as the foundation of learning, from which formal mathematical concepts or knowledge will be formed from practical problems (Dewantara et al., 2023; Diponegoro et al., 2024; Van Zanten & Van den Heuvel-Panhuizen, 2021).

However, the number of meta-analytic studies on mathematical competence is still limited. Ariati et al. (2022) further investigated the effect of RME on students' mathematical competence, indicating that RME has a strong positive impact on mathematical competence.

Several studies have examined the effects of RME on various aspects of mathematical competence, including spatial skills, kinesthetic skills, communication skills, and problem-solving skills (Ginting et al., 2018; Listiawati et al., 2023). In the same vein, several other studies have shown that the use of RME is associated with significant improvements in students' mathematical competence (Azmi et al., 2018; Sutisna et al., 2018; Wahyuni Ningsi et al., 2022). Meanwhile, authors such as Kusuma et al. (2016), Fauzana et al. (2020), and Sudi et al. (2022) showed that the impact of RME on improving students' mathematical ability was only at an average level. This shows that the impact of RME on students' mathematical ability is not uniform. Moreover, authors Shoffa (2022) and Indrastoto and Mahmudi (2025) evaluated the impact of RME on students' critical thinking ability and found a moderate but significant impact.

However, despite the growing number of studies investigating the effectiveness of RME, bibliometric studies provide a comprehensive overview of the development of RME research over time remain limited.

Although previous studies have provided valuable insights into the effectiveness of RME, most have focused on learning outcomes and instructional impacts. Less attention has been paid to understanding the overall development of RME research through bibliometric approaches. Therefore, this study seeks to provide a broader understanding of the evolution of RME research.

The choice of this research topic stems from several key motivations:

- (1) *Understanding the global landscape of RME:* While RME originated in the Netherlands, its adoption and adaptation have spread globally. This research aims to map and analyze this global expansion, identifying key players, influential publications, and emerging trends in global RME research. Understanding this broader context is crucial for appreciating the diverse interpretations and applications of RME in different cultural and educational settings.
- (2) *Identifying research gaps and opportunities:* By analyzing the existing literature, this study seeks to identify areas where RME research is robust and areas where further investigation is needed. This can help researchers focus their efforts on addressing critical gaps in knowledge and contribute to the ongoing development and refinement of RME principles and practices.
- (3) *Informing practice and policy:* The findings of this research can provide valuable insights for educators, curriculum developers, and policymakers interested in implementing or adapting RME in their own contexts. By understanding the trends and best practices identified in the literature, they can make informed decisions about how to effectively integrate RME into mathematics education.
- (4) *Leveraging bibliometric analysis tools:* VOSviewer and CiteSpace are powerful tools for visualizing and analyzing complex networks of bibliographic data. This study employs these tools to examine publication trends, influential authors, institutional and international collaborations, citation structures, and emerging research themes within the RME literature. By combining the strengths of both tools, the analysis can offer a more robust and insightful perspective than either tool could provide alone.

While the preceding discussion synthesizes conceptual perspectives, theoretical foundations, and empirical findings on RME, the remainder of this study shifts to a systematic bibliometric analysis. The subsequent sections detail the data sources, eligibility criteria, and mapping procedures—utilizing VOSviewer and CiteSpace—employed to quantitatively examine global research trends and structural patterns in the RME literature from 2000 to 2025.

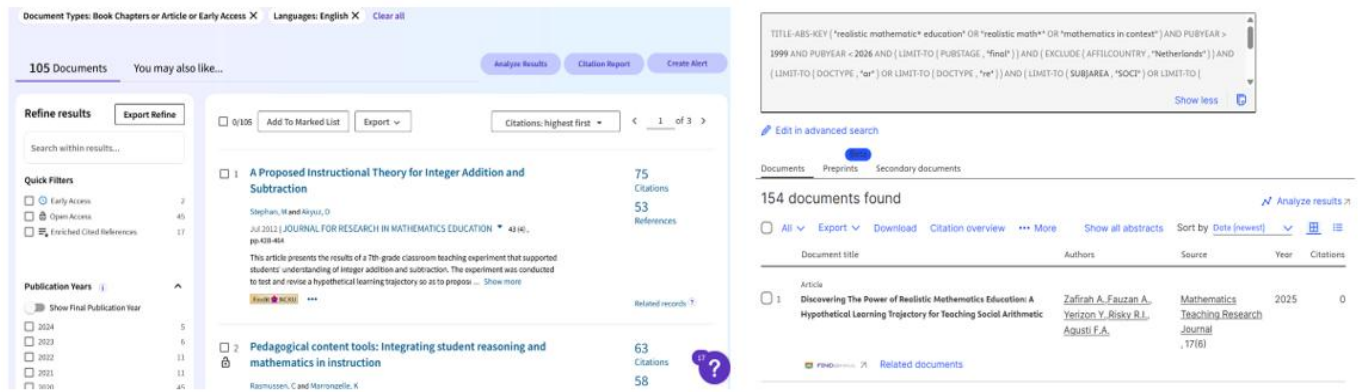


Figure 1. WoS and Scopus data source (the authors' own elaboration)

DATA SOURCE, MATERIALS, AND TOOL AND METHODS

Data Source

In this study, Web of Science (WoS) and Scopus were selected as the primary databases for data collection and analysis. These two platforms are globally recognized as the most comprehensive and prestigious data sources for bibliometric analysis.

WoS

WoS is one of the high-quality digital databases that has been widely adopted by researchers worldwide and has become a popular tool for retrieving and evaluating various types of publications (Thelwall, 2008). WoS has a wide variety of publications from various fields, including more than 15,000 journals and 50,000,000 publications classified in 251 categories and 150 research fields (Merigó & Yang, 2017). In addition, WoS is a suitable database because it contains a set of data, such as title, author, institution, country, abstract, keywords, references, citations, impact factor, and other data (Gaviria-Marin et al., 2019). WoS is considered an ideal data source for bibliometric research (Fang et al., 2018). It has been used in bibliometric analysis in many social science studies (Dissanayake et al., 2022; Fang et al., 2018). It is an up-to-date scholarly database and is also recommended by Chen (2006), the creator of CiteSpace, as the preferred database when using CiteSpace software. Therefore, we chose WoS as the data source in this study. Second, to obtain high-quality articles and exclude noise articles, the WoS core collection was selected as the final data source, not all databases (see **Figure 1**).

Scopus

Scopus is widely recognized as a premier academic bibliometric database, distinguished by its extensive coverage and rigorous validation processes. It provides comprehensive multidisciplinary access and flexible citation linking, serving as an effective complement to the WoS framework. The reliability of this platform is well-established, with national bibliometric indices demonstrating a near-perfect correlation with traditional

evaluation systems. Furthermore, its vast journal catalog and daily updates guarantee high data timeliness and accuracy. As a trusted primary data source, this database is heavily relied upon by major global university rankings and national research assessments. Finally, stringent quality control overseen by an independent advisory council ensures robust transparency, making it an ideal tool for large-scale measurable research.

Therefore, to ensure a comprehensive and rigorous data coverage, this study integrated both WoS and Scopus as the final data sources. Furthermore, to obtain high-quality articles and exclude noisy data, the WoS core collection was specifically selected instead of all WoS databases, while equivalent quality filters were applied to the Scopus dataset (see **Figure 1**).

Materials

The global literature on RME was examined in the WoS online database. The search string applied to find manuscripts with similarities for clustering was: “realistic mathematics education”. All data were collected on January 19, 2025. Several features for documents that met the prerequisites were extracted. These features included

- (1) author(s),
- (2) journal,
- (3) year of publication,
- (4) article type,
- (5) subject,
- (6) number of citations,
- (7) quartiles, and
- (8) emerging topics with explosive levels.

We identified five themes:

- (1) the impact of RME on student achievement and engagement,
- (2) implementing RME in diverse classrooms and contexts,
- (3) teacher education and professional development for RME,
- (4) critical perspectives on RME and its limitations, and
- (5) the evolution of RME theory and practice.

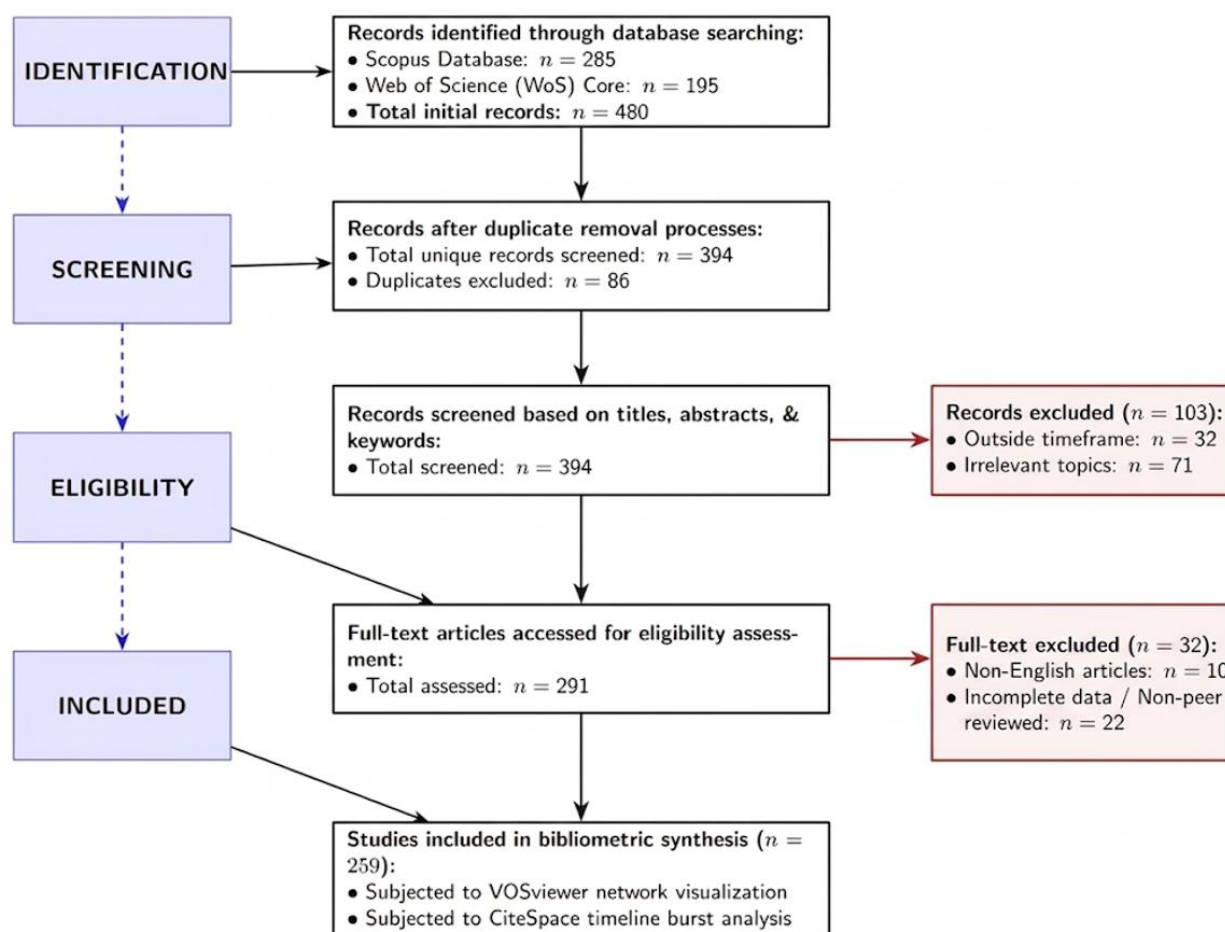


Figure 2. Flowchart of the study (the authors' own elaboration)

An article can contain more than one topic. The quartile analysis was used for evaluating the journal's metrics. The journal's quartile was calculated based on the journal's position in its subject category (category ranking). It was configured as a position indicator: from the first (best) quartile or Q1 to the fourth (worst) quartile or Q4. The best Quartile was used if two or more categories were detected. The source was Journal Citation Reports™ 2025 (Clarivate Analytics).

Tool and Methods

This study employed two software:

- (1) VOSviewer (version 1.6.20) and
- (2) CiteSpace software.

VOSviewer is a software tool for structuring and visualizing bibliometric networks. VOSviewer can analyze scientific interconnections, such as journals, authors, or individual publications, based on citations, bibliographic couplings, co-citations, or co-authorship relationships. Furthermore, it enables text mining to create and visualize co-occurrence networks of key terms extracted from a body of scientific literature. In this research, VOSviewer was utilized to analyze country-level co-authorship, keyword co-occurrences, co-citations, and to identify the most productive organizations and their associated networks.

CiteSpace has a wide range of applications in scientific research. Researchers can use CiteSpace to identify emerging trends in scientific fields, analyze the development and evolution of research topics, and identify authors, organizations, and documents that have had a major impact on their research areas of interest. CiteSpace can help promote research collaboration in interdisciplinary scientific fields. CiteSpace software has great potential for visualizing and analyzing citation networks, which play an important role in helping researchers better understand the development and structure of scientific fields. CiteSpace generates citation maps that highlight important "nodes" in the research system, including influential papers and key citations. This not only helps researchers identify important papers, but also helps to detect gaps in the research, or unexplored research trends. In addition, CiteSpace excels at temporal analysis, enabling researchers to trace the evolution of scientific disciplines over time. A key feature is its burst detection algorithm, which effectively pinpoints sudden surges in citation frequency, shedding light on emerging research trends. Furthermore, CiteSpace offers a wealth of analytical capabilities and sophisticated thematic mapping tools. However, the software's complexity, particularly its steep learning curve, presents a significant challenge for some users. The flow chart of the study is given in **Figure 2**.

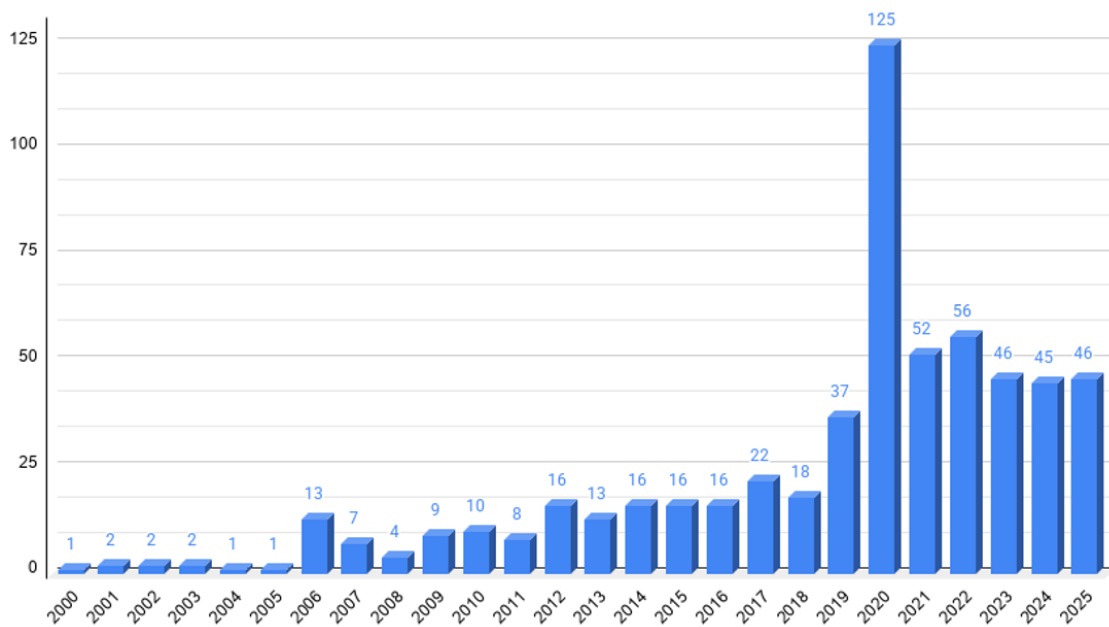


Figure 3. Annual number of documents and trend (the authors' own elaboration based on the data from WoS and Scopus)

RESULTS

Figure 3 illustrates the evolution of the number of publications and citations on the topic of RME from 2000 to 2025. The period 2000-2005 had a slow start, with the number of publications ranging from 0 to 2 articles per year and very low citations, indicating that RME had not received much attention or interest. From 2006 to 2019, the number of publications and citations gradually increased, with 37 articles published and 39 citations in 2019. This period marked steady growth and increasing attention from the academic community.

2020 marked a period of substantial growth for RME with 125 publications and 53 citations, reflecting increased scholarly interest in the RME field. However, from 2021 onwards, publication output fluctuated at a relatively high level, with 52, 56, 45, 45, and 46 publications recorded in 2021, 2022, 2023, 2024, and 2025, respectively. However, the

number of citations peaked in 2024 with 107 citations, then dropped sharply to 6 in 2025. This may be due to the fact that the data were extracted in January 2025, when many RME publications may not yet have been fully indexed in the WoS database. Therefore, the citation count for 2025 should be interpreted with caution. The lower publication and citation counts observed after 2020 may reflect a stabilization of research activity following a period of rapid growth.

Overall, the chart reflects the development cycle of RME from 2000 to 2025, from humble beginnings to a peak in 2020, followed by a sustained level of research activity. These findings indicate that RME has become an established research area and continues to attract scholarly attention, providing opportunities for further investigation and development.

Recently, research on RME has seen significant growth (**Table 1**).

Table 1. The most cited articles

Reference	Article title	Journal	Q	n
Rasmussen and Kwon (2007)	An inquiry-oriented approach to undergraduate mathematics	Journal of Mathematical Behavior	Q1	134
Sumirattana et al. (2017)	Using realistic mathematics education and the DAPIC problem-solving process to enhance secondary school students' mathematical literacy	Kasetsart Journal of Social Sciences	Q3	92
Zandieh and Rasmussen (2010)	Defining as a mathematical activity: A framework for characterizing progress from informal to more formal ways of reasoning	Journal of Mathematical Behavior	Q1	92
Papadakis et al. (2017)	Improving mathematics teaching in kindergarten with realistic mathematical education	Early Childhood Education Journal	Q1	87
Bray and Tangney (2015)	Enhancing student engagement through the affordances of mobile technology: A 21 st century learning perspective on realistic mathematics education	Mathematics Education Research Journal	Q1	85
Larsen and Zandieh (2008)	Proofs and refutations in the undergraduate mathematics classroom	Educational Studies in Mathematics	Q1	78
Stephan and Akyuz (2012)	A proposed instructional theory for integer addition and subtraction	Journal for Research in Mathematics Education	Q1	75
Rasmussen and Marrongelle (2006)	Pedagogical content tools: Integrating student reasoning and mathematics in instruction	Journal for Research in Mathematics Education	Q1	63
Larsen (2013)	A local instructional theory for the guided reinvention of the group and isomorphism concepts	Journal of Mathematical Behavior	Q1	62

Table 1 (Continued).

Reference	Article title	Journal	Q	n
Swinyard (2011)	Reinventing the formal definition of limit: The case of Amy and Mike	Journal of Mathematical Behavior	Q1	47
Johnson and Larsen (2012)	Teacher listening: The role of knowledge of content and students	Journal of Mathematical Behavior	Q1	45
Jupri and Drijvers (2016)	Student difficulties in mathematizing word problems in algebra	Eurasia journal of mathematics science and technology education.	Q3	43
Rasmussen and Blumenfeld (2007)	Reinventing solutions to systems of linear differential equations: A case of emergent models involving analytic expressions	Journal of Mathematical Behavior	Q1	43
Phan et al. (2022)	A bibliometric review on realistic mathematics education in Scopus database between 1972-2019	European Journal of Educational Research	Q2	39
Ke (2019)	Mathematical problem solving and learning in an architecture-themed epistemic game	Educational Technology Research and Development	Q1	39
Yilmaz (2020)	Prospective mathematics teachers' cognitive competencies on realistic mathematics education	Journal on Mathematics Education	Q2	34
Laurens et al. (2018)	How does realistic mathematics education (RME) improve students' mathematics cognitive achievement?	Eurasia journal of mathematics science and technology education	Q3	34
Sevinc and Lesh (2018)	Training mathematics teachers for realistic math problems: A case of modeling-based teacher education courses	ZDM Mathematics Education	Q1	34
Voigt et al. (2020)	Leveraging the design heuristics of realistic mathematics education and culturally responsive pedagogy to create a richer flipped classroom calculus curriculum	ZDM Mathematics Education	Q1	31
Sawatzki (2017)	Lessons in financial literacy task design: Authentic, imaginable, useful	Mathematics Education Research Journal	Q1	30

Note. Q: Quartile & n: Number of citations

According to an analysis by Phan et al. (2022), Indonesia, the United States, and the Netherlands are three leading countries in the application and research of RME, with 282 publications extracted from the Scopus database showing a trend of shifting from traditional models to a more practical approach in mathematics. These studies not only focus on improving learning outcomes but also delve into theoretical aspects such as mathematization, guided reinvention, and emergent models to create a positive learning environment for students at various levels.

In the context of higher education, the IO-DE project by Rasmussen and Kwon (2007) applied the RME teaching design theory to the differential equations course. Instead of transmitting pre-existing formulas, this approach designed a series of learning tasks, stimulating students to actively participate in the mathematization process – independently constructing graphs, algorithms, and definitions under the guidance of the instructor. This process required learners to systematize basic knowledge to form new concepts at a more abstract and general level. On the other hand, the experimental results of Rasmussen et al. (2006) at universities in the United States and South Korea also showed the potential of applying the RME theoretical framework at the university level. The study confirmed that, although there was no significant difference in computational skills, students learning using the RME method scored significantly higher on tests of mathematical concept understanding. This view was further reinforced by the research of Rasmussen and Blumenfeld (2007), which affirmed that applying RME to the teaching of differential equations helps learners develop new mathematical

thinking and increasingly sophisticated proportional reasoning abilities.

On another front, studies in abstract algebra and geometry have expanded the application of RME to other complex mathematical concepts. Swinyard (2011) demonstrated the effectiveness of guided reinvention, as students can independently construct the definition of a limit without prior direct instruction. For the field of algebra, Larsen (2013) developed the local instructional theory, establishing a pedagogical pathway that allows students to independently discover the concepts of group structure and isomorphism, starting from practical experiences with symmetry in geometry.

For primary and preschool levels, RME is applied to build basic mathematical foundations such as arithmetic and word problem solving. Stephan and Akyuz (2012) successfully tested the vertical number line model to help 7th-grade students understand integer operations through the context of asset and debt management. In Indonesia, Jupri and Drijvers (2016) pointed out that the biggest barrier for 7th-grade students when solving real-world problems lies in the horizontal mathematization process, which is understood as converting problem data into a mathematical model. To overcome this, Sumirattana et al. (2017) combined RME with the DAPIC problem-solving process (define, assess, plan, implement, and communicate), helping 104 9th-grade students in Thailand significantly improve their mathematical abilities and their ability to apply knowledge to real-world situations. Even at the preschool level, Zaranis et al. (2013) demonstrated that RME activities based on real-world experiences, such as shopping, help children develop

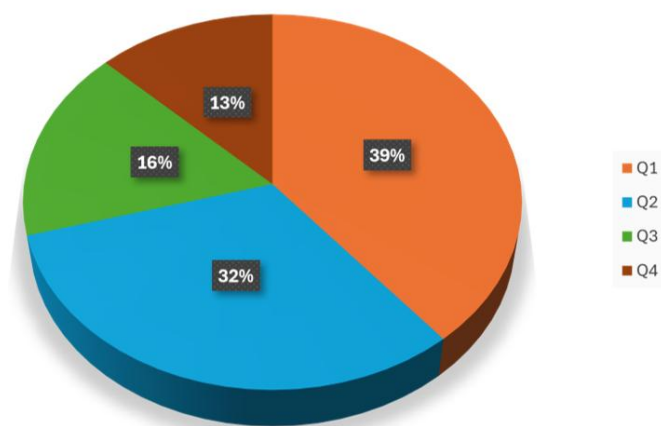


Figure 4. Quartile analysis (the authors' own elaboration)

logical thinking and number sense more effectively than traditional methods.

On the other hand, the combination of RME and digital technology along with educational games is becoming a cutting-edge research direction. Ke (2019) used a 3D architectural simulation game (E-Rebuild) to encourage 61 sixth-grade students to solve mathematical tasks related to ratios and areas. Experimental results showed that the group learning through this combined method achieved superior learning outcomes compared to the control group. Similarly, Laurens et al. (2018) combined RME with the snake and ladder game to develop geometric thinking in middle school students in Ambon, Indonesia. Notably, the study by Voigt et al. (2020) in Norway integrated RME's instructional design theory with culturally responsive pedagogy in a flipped classroom model, helping calculus students utilize video lessons as a practical resource to build vector concepts. The integration of technology into the RME theoretical framework has opened a new direction for mathematics education: technology is no longer a purely supportive tool but has become a vibrant 'real-world environment' that personalizes the learning path and optimizes the learner's self-construction of knowledge.

However, the widespread implementation of RME still faces significant barriers regarding the professional competence of the teaching staff. Yilmaz (2020) points out that although most teachers have a firm grasp of RME theory, their ability to design contextual problems and differentiate RME from other teaching methods remains limited. This challenge is also found at the university level. Johnson and Larsen (2012) also point out that instructors struggle to guide learners due to a lack of in-depth knowledge of content and students, thereby emphasizing the importance of developing pedagogical competence

rather than focusing solely on specialized mathematical knowledge. To address this situation, Sevinc and Lesh (2018) propose modeling-based training courses to shift teachers' teaching perspectives: from focusing on abstract concepts to considering real-world context as the core means of stimulating mathematical thinking. Rasmussen and Marrongelle (2006) also developed pedagogical content tools, such as transformational records and generative alternatives. These tools serve as effective bridges, helping teachers closely link students' natural thinking with formal mathematical representations

The quartile analysis demonstrated that 39% of papers were published in Q1, 32% in Q2, 16% in Q3 and 13% in Q4 (Figure 4).

Table 2 shows that, within the WoS subset (n = 105), the "BKCI-SSH" index accounts for the highest proportion (43.810%), reflecting the strong focus on research in the social sciences and humanities through citations from books. This is followed by the "BKCI-S" index, which accounts for 38.095%, indicating a significant contribution from research in the natural sciences. Citations from social science journals, represented by the "SSCI" index, account for 28.571%, confirming the important role of these sources in the research dataset. In addition, "ESCI" accounts for 25.714%, which has shown a significant increase in citations from emerging and developing research. However, the "SCI-EXPANDED" index accounts for only 1.905%, indicating that this field has a very limited role in current research. An overview of the data shows that citations from books and journals in the social sciences and humanities play a dominant role, while emerging sources and natural sciences still have the potential to expand in the future.

Co-Citation of Cited Author

Based on the VOSviewer co-citation data table and map (Figure 5), it can be seen that RME research revolves around a network of influential authors. Gravemeijer is the central author, with 136 citations and the highest level of links (115.57), reflecting the importance of the researcher in the development of RME theory and its application in practical education. Freudenthal (1991), the founder of RME theory, also holds an important position with 105 citations and 93.03 links, emphasizing the author's fundamental role in theoretical and philosophical research in mathematics education.

In addition, Van den Heuvel-Panhuizen (2003) and Treffers (1993) further expanded the scope of RME research, focusing on aspects such as curriculum design and learning assessment. The co-citation map shows that authors are divided into several clusters of research focus. The red

Table 2. Documents are classified by WoS (n = 105)

Field	Record count (n)	Percentage of 105 (%)
Book Citation Index – Social Sciences & Humanities (BKCI-SSH)	46	43.810
Book Citation Index – Science (BKCI-S)	40	38.095
Social Sciences Citation Index (SSCI)	30	28.571
Emerging Sources Citation Index (ESCI)	27	25.714
Science Citation Index Expanded (SCI-EXPANDED)	2	1.905

Country	Documents	Citations	Total link streng
usa	22	272	471.63
netherlands	23	60	269.14
norway	10	68	241.3
turkey	5	80	175.51
australia	3	1	149.92
south africa	5	11	114.59
argentina	2	25	110.16
indonesia	11	125	85.87
mexico	2	0	62.00
vietnam	2	4	49.00
peoples r china	3	6	45.03
south korea	2	29	40.94
sweden	2	15	38.33
denmark	3	7	31.83
turkiye	2	1	28.95
greece	2	27	27.00
belgium	3	45	26.73
germany	3	10	25.96
portugal	2	7	24.88
spain	3	6	24.20

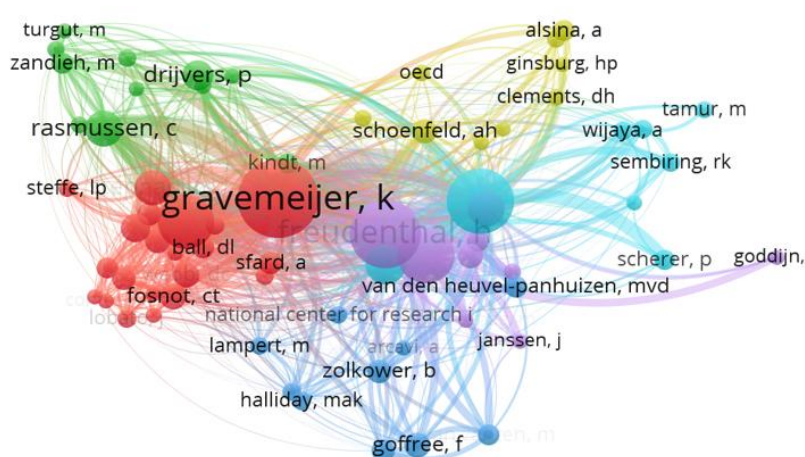


Figure 5. Data tables and author co-citation maps (the authors' own elaboration based on the data from WoS and Scopus using VOSviewer)

Country	Documents	Citations	Total link stren
usa	22	272	471.63
netherlands	23	60	269.14
norway	10	68	241.3
turkey	5	80	175.51
australia	3	1	149.92
south africa	5	11	114.59
argentina	2	25	110.16
indonesia	11	125	85.87
mexico	2	0	62.00
vietnam	2	4	49.00
peoples r china	3	6	45.03
south korea	2	29	40.94
sweden	2	15	38.33
denmark	3	7	31.83
turkiye	2	1	28.95
greece	2	27	27.00
belgium	3	45	26.73
germany	3	10	25.96
portugal	2	7	24.88
spain	3	6	24.20

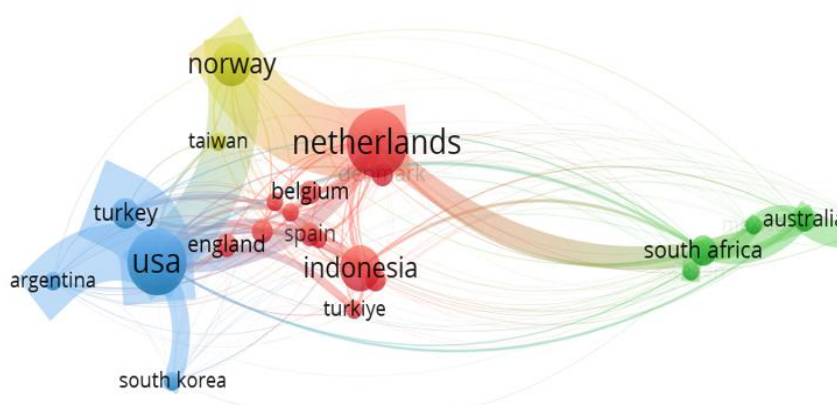


Figure 6. Data table and network map of countries by research topic on RME (the authors' own elaboration based on the data from WoS and Scopus using VOSviewer)

cluster, including authors such as Gravemeijer and Cobb focuses primarily on the development and application of teaching methods based on RME theory, such as “guided reinvention”. The blue cluster, including Van den Heuvel-Panhuizen (2003) and Freudenthal (1991), focuses on curriculum development and methods for evaluating the effectiveness of RME in educational settings. In addition, the green and yellow clusters represent ancillary research, including the integration of technology, the analysis of mathematical thinking, and the extension of RME to new areas such as primary education.

The distribution of author clusters and the strong links between them reflect the interdisciplinary and close collaboration in RME research. This shows that RME is not only an educational theory but also a practical, highly applicable method with the potential to create significant improvements in mathematics teaching. In the future, research can focus on integrating digital technology and personalized learning based on the philosophy of RME to meet the increasingly diverse needs of students.

Co-Authorship for Countries

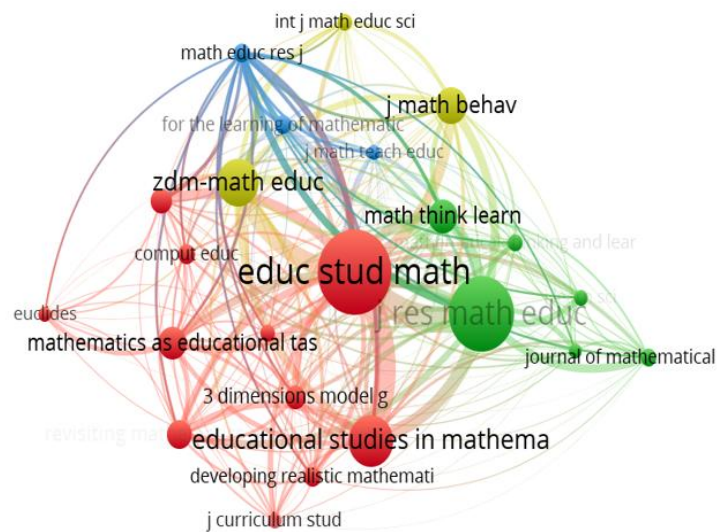
By selecting a minimum number of documents of a country of 3, the software produced 21 countries, and 6 met

the threshold. An amount of 22 documents and 272 citations were obtained from the United States (total link strength: 471.63); 23 documents and 23 citations were obtained from the Netherlands (total link strength: 269.14). Finally, 10 documents and 68 citations (total link strength: 241.3) were obtained from Norway (Figure 6).

Other countries such as Indonesia and Turkey also made significant contributions. Norway had 10 papers and a linkage score of 241.30, reflecting a close research relationship despite a lower number of papers. Indonesia ranked fourth with 11 papers, 125 citations and a linkage score of 85.87, indicating strong potential for growth in the field of real mathematics, especially as the international research community becomes more interested in research from this area. Meanwhile, Turkey had fewer papers (5) but achieved 80 citations, demonstrating good research quality.

The network map shows countries with strong collaborations, with the United States and the Netherlands being research hubs with many links. Clusters of countries such as Norway, Turkey, and Indonesia are linked through research partnerships. Countries such as South Africa, Argentina, and Australia play a supporting role in the network, exhibiting lower overall tie strength but still maintaining their involvement in global research.

Source	Citations	Total Link Strength
educ stud math	131	109.68
jr math educ	113	88.82
educational studies in mathematics	70	62.14
zdm-math educ	64	56.78
math think learn	42	40.47
mathematics as educational task	40	40.00
j math behav	47	39.94
revisiting mathematics education: china lectures	34	34.0
encyclopedia of mathematics education	28	28.00
3 dimensions model g	27	27.00
developing realistic mathematics education	21	19.07
for the learning of mathematics	20	19.07
math educ res j	20	18.92
journal of mathematical behavior	19	17.67
didactical phenomenology of mathematical structures	17	17.00
mathematical thinking and learning	17	16.82
j curriculum stud	18	16.46
int j math educ sci	17	15.79
j learn sci	16	15.17
int j math teach educ	15	14.84



Overall, RME research has seen significant participation and contributions from a number of leading countries, with the United States and the Netherlands playing a central role. However, other countries such as Indonesia, Norway and Turkey have also contributed significantly, especially in improving the quality of research and expanding international cooperation.

Based on the data table and journal co-citation map (Figure 7), it shows that the research field of RME is built on a highly interconnected literature network, focusing on sources that play a core role in shaping the theory and practice of mathematics teaching. Among them, the journal “Educational Studies in Mathematics” (educ stud math) holds a central position with the highest number of citations (131) and the greatest degree of interconnection (109.68). This is a core document that is frequently cited by researchers, indicating its leading role in providing the theoretical and empirical foundation for RME.

The journal co-citation map shows the clear formation of research clusters, represented by different colors. Large clusters, such as the red cluster (center), represent popular, general, and foundational literature, while smaller clusters, such as the blue and yellow clusters, focus on specialized research branches such as student behavior (j math behav) or the development of mathematical thinking (math think learn). Notably, documents such as “Developing realistic mathematics education” and “3 dimensions model G” reflect

Co-Occurrence of Author Keywords

The co-citation map of keywords is clearly clustered within research areas. The blue cluster, which includes the keywords “guided reinvention” and “progressive formalization”, emphasizes guided discovery learning, where students construct their own knowledge from real-world situations. The red cluster focuses on disciplinary content such as “algebra” and “differential equations”, reflecting an interest in applying RME in specific areas of mathematics. Meanwhile, the yellow cluster is associated with curriculum development and teacher beliefs, suggesting that the success of RME depends not only on content but also on teacher competence.

In general, research on RME not only focuses on mathematical content but also extends to the areas of teaching methods, curriculum and teacher training. This provides a solid basis for developing teaching materials and educational plans based on a practical approach, helping students not only learn mathematics well but also understand deeply and apply knowledge to real life.

Keyword	Occurrences	Total link strength
Realistic mathematics education	46	46.00
Mathematics education	4	4.00
Professional development	4	4.00
Early childhood education	3	3.00
Modeling	3	3.00
Problem solving	3	3.00
Algebra	3	3.00
Representations	3	3.00
Curriculum	2	2.00
Differential equations	2	2.00
Guided reinvention	2	2.00
Mathematics curriculum	2	2.00
Multiplicative reasoning	2	2.00
Pre-service teachers	2	2.00
Progressive formalisation	2	2.00
Proportional reasoning	2	2.00
Realistic mathematics education (rme)	2	2.00
Teacher beliefs	2	2.00
Textbooks	2	2.00
Theory of didactical situations	2	2.00

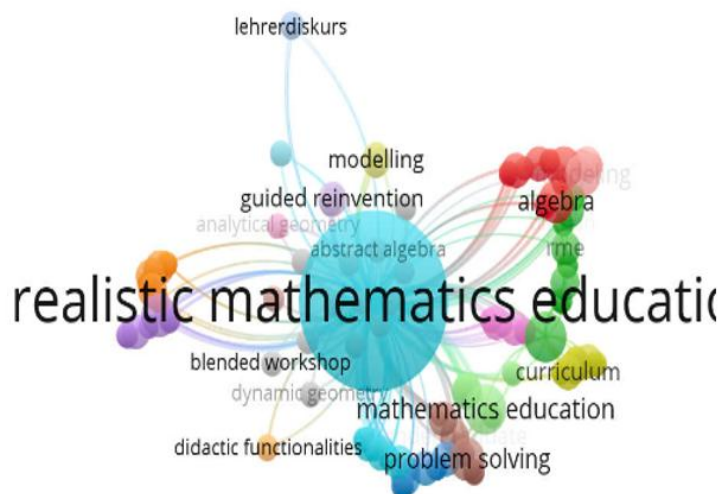


Figure 8. Data table and co-citation map of keywords by research topic on RME (the authors' own elaboration based on the data from WoS and Scopus using VOSviewer)

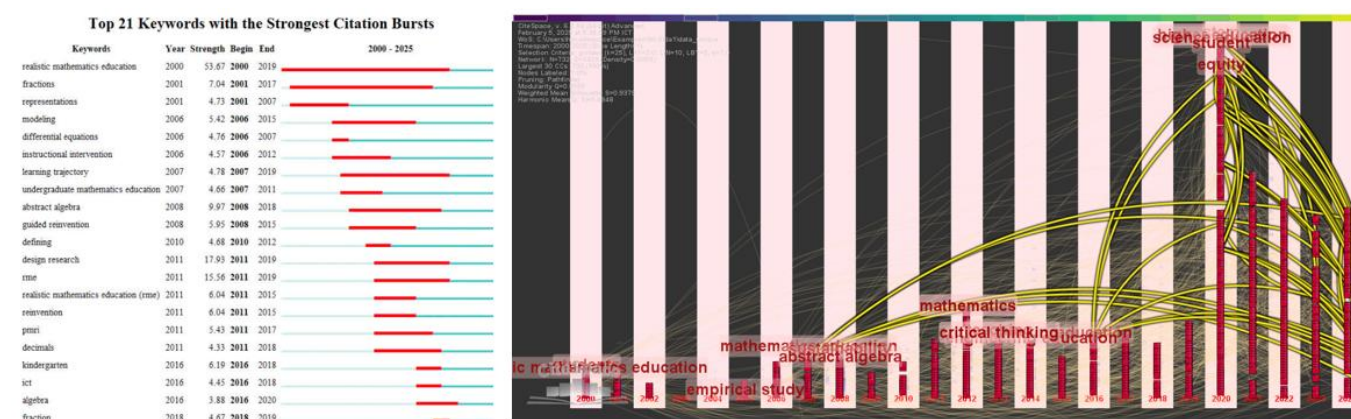


Figure 9. Data table and map of RME by time slice (the authors' own elaboration based on the data from WoS and Scopus using CiteSpace)

Trend of RME

The data table and time-slice map of keywords in RME from 2000–2025 show the change in research focus over time (Figure 9). “Realistic mathematics education” appears prominently with the highest citation level (54.54), spanning from 2000 to 2019, demonstrating its core role in mathematics education research. Keywords such as “fractions”, “representations”, and “modeling” dominate the period 2000–2010, reflecting research focusing on practice-based teaching methods and problem-solving skills. Since 2010, the research focus has gradually shifted to concepts related to instructional design and improvement, such as “design research” and “guided reinvention.” This is reflected in the expanding connections between keywords in the timeline map, reflecting the close relationship between research areas such as “abstract algebra” and “instructional intervention.” These keywords are not only theoretical developments but also highly applied, emphasizing the improvement of educational practice.

The time-slice map shows complex connections between topics, from basic mathematical concepts such as

“integrators” and “differential equations” to more advanced elements such as “mathematical reasoning” and “conceptual change.” This reflects a strong interest in building students’ mathematical thinking skills. In the period 2020 – 2025, the research trend gradually shifted to technology and equity factors in education, with the prominence of keywords such as “virtual reality”, “equity” and “student education.” This shows the increasing importance of digital technology in promoting realistic and personalized learning experiences. At the same time, concepts such as “design thinking” expand the possibilities for creativity and innovation in curriculum development.

Overall, the timeline map and data table together show a consistent trend of development between foundational theories and advanced technologies, creating a comprehensive picture of the progress of RME. Future trends are likely to continue to focus on sustainability, innovation, and equity in mathematics education, in line with the development of today’s modern world.

DISCUSSION

This study utilized VOSviewer and CiteSpace to analyze bibliographic data on RME research published between 2000 and 2025, providing valuable insights into the field's development trends. The network visualizations generated offer a comprehensive overview of the key themes, influential authors, and prominent countries shaping RME research internationally.

The analysis confirmed the central role of RME within mathematics education, with “realistic mathematics education” itself consistently emerging as the most prominent keyword. This underscores the continued relevance and impact of the RME approach in shaping pedagogical practices and research agendas globally. The high degree of connectivity associated with RME further emphasizes its integration within a broader network of related concepts, such as “mathematics education,” “guided reinvention,” “curriculum,” and “problem solving.” This interconnectedness highlights the holistic nature of RME, its influence on various aspects of mathematics education, and its contribution to fostering student-centered learning environments.

The co-citation analysis revealed influential authors and research clusters that have significantly contributed to the RME literature. Identifying these key players provides a valuable resource for researchers seeking to engage with the foundational and cutting-edge work in the field. Furthermore, the clustering of keywords and authors allows for the identification of specific research niches within RME, such as the application of RME in specific mathematical domains (e.g., geometry and algebra), the integration of technology into RME-based instruction, or the exploration of the impact of RME on student learning outcomes.

The geographic analysis highlighted the varying levels of engagement with RME research across different countries. While the United States and the Netherlands emerged as dominant forces, the contributions from other countries underscore the growing international interest in RME. Further research could explore the contextual factors that contribute to the adoption and adaptation of RME in diverse educational settings, including cultural influences, curriculum standards, and teacher training programs. It is also important to note that the analysis focused on publications indexed in the chosen databases. Future research might consider expanding the scope of the analysis to include other sources, such as conference proceedings, dissertations, and grey literature, to provide a more complete picture of RME research activity.

The timeframe of 2000–2025 provides a contemporary snapshot of RME research. Analyzing how these trends have evolved over time, and anticipating future directions, would be a valuable extension of this study. For example, exploring the emergence of new research themes related to digital learning environments or the integration of

interdisciplinary approaches within RME could provide insights into the future trajectory of the field.

Besides identifying publication trends and research networks, the bibliographic map also provides important insights into the future direction of research on RME. The prominence of topics related to the process of learning mathematics, training programs, and teaching practices shows that RME has reached a relatively mature stage, serving as a pedagogical framework in mathematics education. However, these maps also point out some areas that have not yet been deeply explored. Specifically, topics related to technology seem to remain relatively obscure compared to traditional topics, suggesting potential for future research to explore how to integrate RME with digital learning environments, artificial intelligence, and data-driven educational methods. Furthermore, the limited appearance of interdisciplinary topics indicates that the application of RME outside the scope of traditional mathematics classrooms has not yet received adequate attention. Therefore, future studies may explore the potential of RME in STEM education models and other interdisciplinary contexts. The geographical distribution of scientific publications also underscores the need for further comparative and cross-cultural research to better understand how RME principles are adapted and implemented across different educational systems. Addressing these orientations will not only broaden the scope of the RME field but also enhance the relevance and responsiveness of this approach in addressing current educational challenges.

CONCLUSION

This study employed bibliographic network analysis using VOSviewer and CiteSpace to investigate global research trends in RME from 2000 to 2025. The analysis successfully identified key themes, influential authors, prominent countries, and the interconnectedness of concepts within the RME research landscape. The findings confirm RME's central position within mathematics education research, highlighting its continued relevance and impact on pedagogical approaches. The study revealed a strong focus on student-centered learning, guided reinvention, and problem-solving within the RME literature. Furthermore, the analysis identified influential researchers and research clusters, providing a valuable resource for those seeking to engage with foundational and cutting-edge work in the field. While the United States and the Netherlands emerged as significant contributors, the growing global interest in RME is evident through contributions from other countries.

Besides shaping the knowledge structure of the field, this study also offers several important implications for future research and educational practice. For researchers, the identified thematic trends and research models reveal numerous opportunities to expand RME research into emerging areas, including digital learning environments,

interdisciplinary education, and cross-cultural studies on the implementation of RME in diverse educational contexts. For teachers and educators, the research findings reaffirm the value of designing mathematics teaching activities linked to meaningful real-world situations, thereby supporting learners in developing conceptual understanding and problem-solving skills. For policymakers and curriculum developers, the increasing international spread of RME highlights the importance of promoting context-oriented and learner-centered approaches to mathematics teaching in educational programs, while strengthening professional development programs for teachers to support the effective implementation of RME. Future research could further expand on this by analyzing the development of thematic trends over longer periods, integrating more diverse data sources, and considering contextual factors influencing the adaptation and effectiveness of RME implementation in diverse educational environments.

This study provides a comprehensive overview of RME research trends, offering valuable insights for researchers, educators, and policymakers. The identified trends can inform future research directions, pedagogical practices, and curriculum development, ultimately contributing to the advancement of mathematics education through the effective implementation and evolution of RME principles. Future research might expand upon this study by exploring the evolution of these trends over time, incorporating additional data sources, and investigating the contextual factors influencing RME adoption in diverse settings.

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