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A Bibliometric Review on Realistic Mathematics Education Database Between 2000-2022

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Abstract: Although there is a high demand for approaches to teaching "real mathematics" today, little is known about its current state. To bridge this gap, this research aims to review 506 studies on the transmission of "real mathematics" from the Scopus database between 2000 and 2022This study tackles four issues using descriptive and bibliometric analyses: (i) overall size, growth trajectory, and geographic distribution; (ii) most significant authors and research teams in this subject; and (iii) sources with the most sway in this field (i.e., journals, books, conferences); and (iv) how many of the research papers written for the RME method are focused on the impact of students on their results.

Keywords: bibliometrics, mathematics education, mathematics in context, real mathematics, Scopus.
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Introduction

It is mandatory to teach mathematics at every stage of school education. Therefore, it is necessary to study at primary, secondary, and higher educational institutions. Cockcroft (1982) identifies why mathematics should be taught. Reasons: 1) Mathematics is necessary and useful in daily life, science, business, and industry. 2) Mathematics provides a powerful, compact, and understandable communication tool that can be used as a tool for critical thinking in describing and predicting. It can also be considered that mathematics has become the main capital of life. Real-life situations and experiences are essential in creating directions for mathematical thinking. Numerous research Gingsburg, Klein and Starkey (1989), Greeno (1991) have demonstrated that the use of informal skills in daily life leads to the emergence of mathematical notions. This growth must be supported by the application of mathematical knowledge to practical circumstances.

In fact, mathematics is a difficult subject for students of all levels of knowledge. Nowadays, mathematical activities in the classroom tend to focus more on procedural calculations than the mathematical meaning behind these activities (Uça, 2014). Activities in math classes often involve exercises designed to teach calculation rather than the underlying meanings. As a consequence, students find it difficult to comprehend the mathematical concepts incorporated into exercises that are connected to their everyday lives. In actuality, mathematics is a challenging topic for kids at all academic levels (Ke, F. 2014).

Additionally, according to Crespo (2000), Jansen and Spitzer (2009), and Morris (2006), students in current mathematics programs simply evaluate the solution to a problem—whether it is correct or incorrect—and do not take the process into account. These conclusions, despite the importance of the links between mathematical knowledge and everyday life, allow students to see mathematics as only one "subject" without realizing the relationship of mathematical knowledge to real life.

The Program for International Student Assessment (PISA) measures the readiness of 15-year-old learners in Organization for Economic Co-operation and Development (OECD) member countries to deal with real-life problems at the conclusion of compulsory education. The Organization for Economic Cooperation and Development (OECD) released the initial findings of the PISA-2018 worldwide research towards the end of 2019.

The worst result in history was by Kazakhstan. Students from 79 different nations and economies participated in the study. The 15-year-olds from Kazakhstan placed 69th. For Kazakhstan, the initial experience in 2009 posed significant difficulties. Out of 69 nations, it was rated 59th at the time. 200 educational institutions and 5590 students participated in the test. The outcome in 2012 was marginally better. 5808 pupils from 218 institutions, including 2286 from schools where Russian is the primary language of instruction and 3522 from those where Kazakh is the primary language of instruction. The final ranking is 45th out of 65 competing nations. Although the nation's performance has been advancing since 2009, it declined in 2018.

Based on the results of PISA, students from Kazakhstan are able to perform calculations according to a certain algorithm, extract results from the source, and directly prove the given process. However, they did poorly in terms of conceptualizing, generalizing, and using information based on their research and simulations.

Ersoy (2003) emphasized that innovative methods and ideas of teaching are carried out in research setting to solve existing problems in the education system. Experts have also looked at how new methods have an effect on the processes of instruction and learning in this area (Esoy, 2003). In affluent nations, student-centered methods of math instruction and learning have recently taken the lead. Numerous studies have been done on the creation of student-centered mathematics education programs and curricula.

Pedagogical approaches to teaching mathematics, reflecting the importance of students' daily experiences in real life, are diverse. One of the newest approaches to teaching mathematics, which focuses primarily on the daily lives and experiences of students, is the Real Mathematics Education Method (RME).

RME was developed as part of the "Institute for the Development of Mathematical Education" (Instituut Ontwikkeling WiskundeOnderwijs, IOWO), founded at the University of Utrecht (Wittmann, 2005).
The project was started in 1968 by Edu Wijdeveld, Fred Goffrey, and Adri Treffers and became more important with the participation of Hans Freudenthal (Van den Heuvel-Panhuizen, 2003; Treffers, 1993) within the Wiskobas

project (Elementary Mathematics Project). Van den Heuvel Panhuizen and Drivers, 2014; Treffers, 2003).The main goal of the project is to protect Dutch mathematics education from the "new mathematics" emerging in the USA and to provide a real mathematics education free from traditional arithmetical conventions. IOWO was renamed the Freudenthal Institute (FI) because of Freudenthal's significant contribution to the field of mathematics as the most important member of the project and for defining the current principles of RME (Robertson, 2000). This approach, developed by the Freudenthal Institute, is used in Germany, the US, Brazil, Denmark, South Africa, the UK, Spain, Japan, Malaysia, and Portugal, among others.

Based on the structure and composition of published studies, bibliometric analysis was employed to assess scientific activity in 1969. (Alan Pritchard, 1969). Basic bibliometric analysis makes use of statistical techniques to identify shifts in the development of a knowledge base and document "topographical" tendencies in a body of information (Hallinger & Kovaevi, 2019), (White & McCain, 1998). This approach can also be used to identify a research trend and track its advancement over a predetermined amount of time (Binh et al., 2021; Thi-Trinh et al., 2021).

Approaches such as Bibliometric evaluation of postsecondary learning, sustainability, lifelong learning, STEM (Science, Technology, Engineering, and Mathematics) education, and mathematical expertise are widespread in mathematics education research (Drijvers et al., 2020).

In addition, there are only a few studies completed on the basis of the RME technique and even fewer researches available on the quantitative analysis of the RME to gauge the advancement of this research trend in the sphere of mathematics education. However, RME is a significant trend in mathematics education, as Wittmann (2005) observed in his paper at the Freudenthal 100 Symposium.

Therefore, by compiling and synthesizing examples of earlier RME-method research from earlier decades, this work aims to close this gap. The preceding four research questions (RQ) are specifically taken into consideration:

1. What is the overall workload, growth trend, and geographic distribution depending on the RME-method?
2. Which researchers and authors have had the most impact on RME literature?
3. What publications, books, or conferences had the biggest influence on RME literature?
4. What are the most crucial subjects covered in the RME research papers?

Methodology

Pritchard (1969) pioneered bibliometrics as a novel approach to performing reviews. According to Patra et al. (2003), this methodology has been extensively employed in a variety of study areas, including those involving mathematics. For instance, Ozkaya (2018) used 9,941 papers catalogued in the Web of Science between 1980 and 2018 to develop a general framework of the academic research and communication system of the discipline of mathematics education. These studies used a variety of bibliometric analysis techniques (such as statistical descriptions, co-authorship analysis, and scientific mapping) to determine the body of knowledge for the subjects

they were researching. In line with prior studies, this study analyzes 506 Scopus-indexed texts from 2000 to 2022 to address the aforementioned four research topics.

We can examine the topic structure of RME, choose the themes that are most interesting for further study, and carry out research on those topics using relational-magnetic analysis and makes it possible to find patterns (Zupic & ater, 2015). Co-keywords display keywords that recur often in the examined documents (Callon et al., 1986), implying that related papers are those that share some of the concepts listed in the keywords section and address the same subject.

Search criteria identification of sources Scopus

The two most significant scholarly databases that have been often employed in prior bibliometric investigations are Scopus and Web of Science. But rather than the Web of Science, this analysis draws its documents from the Scopus database. The keyword "realistic mathematics education approach" was used in the search query for the Scopus database during the identification stage. Articles and papers including all research works that match this term in their themes, abstracts, or keywords are filtered. This makes it possible to locate the RME method's most important documents. The search term is more specifically as follows: TITLE-ABS-KEY ("Realistic Mathematics Education Approach") ("Realistic Mathematics Education Approach"). The keyword search mentioned above produced 644 results, which were then examined again in the following phase.

To be specific, a set of criteria was used in the selection process to narrow down the pertinent documents: Language: English; Document Type: Unlimited; Subject Area: Unlimited; Publication Year: 2000–2022. Eight publications were disqualified in this phase as a result of publication-year inconsistencies. Due to this, 585 documents were added in the third stage (validation). The third phase was reading each publication's title and abstract in order to assess it. A maximum of 506 academic papers were gathered after the third step.

Results

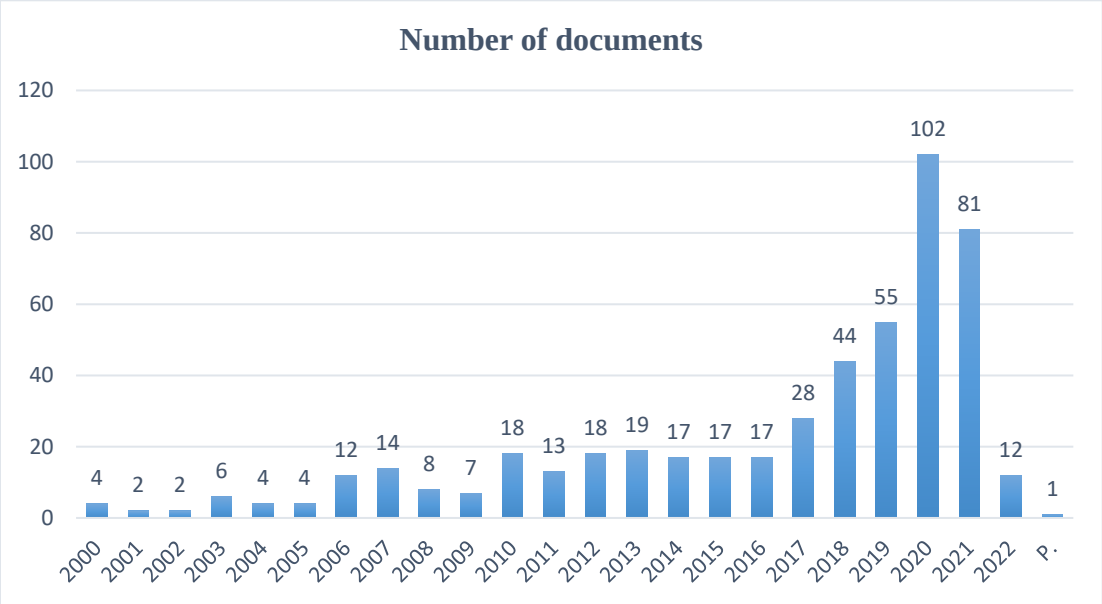
What is the overall workload, growth trend, and geographic distribution depending on the RME-method?

The answers to the initial research question are presented in this section. Through our four-step PRISMA search and matching procedure, 506 documents specifically connected to RME were found and examined.
First of all, let's focus on the growth trajectory. Figure 2 shows the number of documents related to RME, published between 2000 and 2022. In the period of 2000–2016 (16 years), the number of research projects related to RME began to increase. In general, 182 articles were published during this period (per year, 11 articles). However, during this period, the number of research projects related to RME did not exceed 20 in any year. In 2017, the number of published research articles related to RME exceeded 20 per year for the first time. Nevertheless, from 2012 to 2015, the annual number of RME-related studies decreased, with 18, 19, 11, and 19 papers, respectively. The last five years (2017–2022) have seen a significant increase in the number of research articles related to RME. Specifically,

322 RME-related documents (research papers) were published during this period, which is 63.64% of the total 282 documents

Figure 1

Number of RME-related publications between 2000 and 2022 (N = 506)



Regarding the geographical distribution of research work related to RME, the three most significant nations for RME research are Indonesia, the United States, and the Netherlands. (30 countries and 592 authors in total). Specifically, Indonesian researchers have published 215 papers related to RME, accounting for 42.49% of the total of 506 publications. Indicators for the USA and the Netherlands are 82 documents (16.2%), and 29 (5.73%) research works, respectively. As shown in Figure 1, the number of RME-related research papers in countries other than these three countries ranges from 1-15.

Which researchers and authors have had the most impact on RME literature?

In Table 1, the top ten writers of research articles on RME are listed according to the quantity and quality of citations. The authors who have studied RME the most aren't necessarily the scholars who have garnered the most citations due to an intriguing difference between the two categories (in terms of the quantity of articles and citations). For instance, Putri RII is ranked first in the number of papers with 18 RME-related research papers published, totaling 109 citations (ranked sixth among the top 10 authors in citations). Rasmussen C., on the other hand, obtained 331 citations overall (ranked first in citations), but just 11 RME-related research papers (ranked 4th in documents). Indonesian authors dominate the first 10 places in terms of the number of published research works. Among the 16 authors of the top 10 RME authors by papers (2 authors ranked 4th with 11 publications, 2 authors ranked 5th with 10 publications, 3 authors ranked 6th with 8 publications, 2 authors ranked 8th with 6 publications, 10th with 4 publications there are 2 authors, 10 from Indonesia. The 10 most popular RME writers with respect to citations also include US and Dutch

scholars. Four authors from the USA and three from the Netherlands are among the top 10 RME authors by citations (Table 1).

Figure 2

Number of publications in RME by country between 2000 and 2022 (n =506)

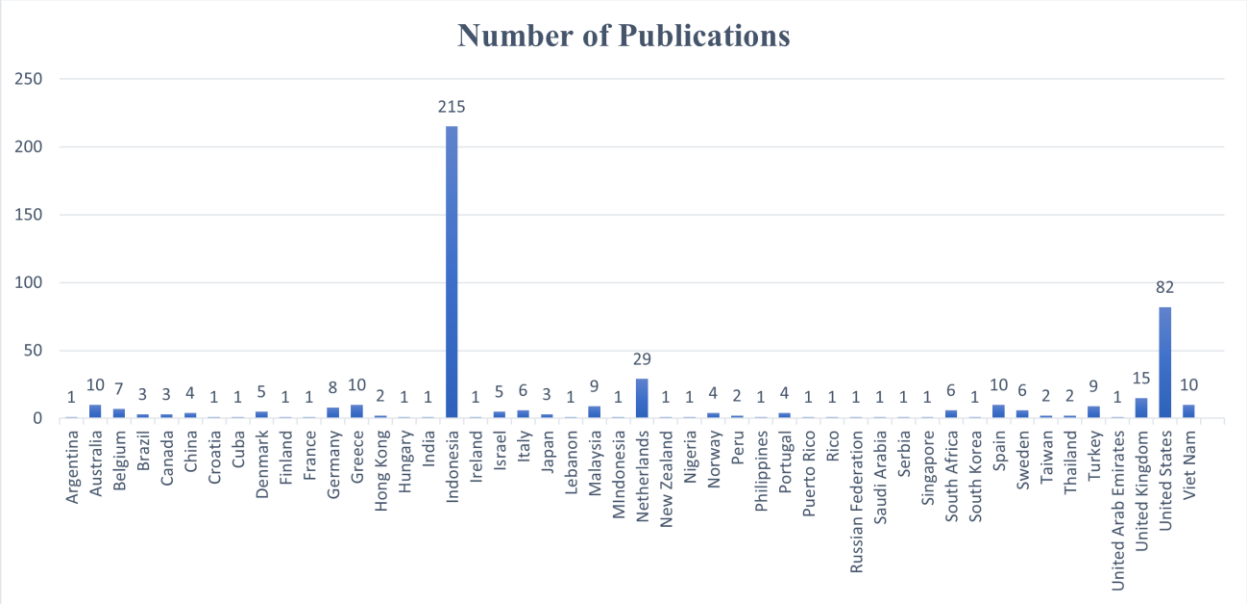


Table 1

Top 10 authors based on the number of citations to research papers on RME between 2000 and 2022

Top 10 RME authors by documentation				**Top 10 RME authors by citations**			
Rating	**The author**	**Relevance**	**Documents**	**Rating**	**The author**	**Relevance**	**Documents**
1	Putri R.I.I.	Universitas Sriwijaya	18	1	Rasmussen C.	San Diego State University, United States	331
2	Fauzan A	Universitas Negeri Padang, Indonesia	17	2	Van den HeuvelPanhuizen M.	Freudenthal Institute, Utrecht University, Netherlands	298

Table 1 continued

3	Arnawa I.M.	Universitas Negeri Padang	13	3	Mo Z.,	Institute of Applied Physics and Computational Mathematics, Beijing, China	150
4	Armiati A.	Universitas Negeri Padang, Indonesia	11	4	Zandieh M.	Arizona State University, Department of Applied Sciences and Mathematics, College of Technology and Innovation, United States	115
4	Rasmusse n C.	San Diego State University, United States	11	5	Prahmana R.C.I.	Master Program on Mathematics Education, Graduated Program, Universitas Ahmad Dahlan, Yogyakarta, Indonesia	113
5	Zubainur C.M.	Universitas Syiah Kuala, Indonesia	10	6	Putri R.I.I.	Univers itas Sriwijaya	109
5	Yerizon Y.	Universitas Negeri Padang, Indonesia	10	7	Stone M.	University of Illinois at Urbana-Champaign, United States	108
6	Suparman	Ahmad Dahlan University, Indonesia	8	8	Lazakidou G.	University of Piraeus	102
6	Darmawij oyo	Universitas Sriwijaya	8	8	Retalis S.	University of Piraeus	102

Table 1 continued

6	Johar, R.	Universitas Sriwijaya	8	8	Artigue M.	Université Paris DiderotParis 7, Paris, France Freudenthal Institute, Utrecht University, Netherlands	102
7	Verschaffel, L.	KU Leuven	7	8	Blomhøj M.	Roskilde University, Roskilde, Denmark	102
8	Jupri, A.	Universitas Pendidikan Indonesia	6	9	Marrongelle K	Department of Mathematics and Statistics, Portland State University, United States	95
8	Zaranis, N.	University of Crete	6	10	Drijvers P	Freudenthal Institute, Utrecht University, Netherlands	73
9	Nursyahidah, F.	Nanyang Technological University	5	/	/	/	/
10	Albab, I.U.	Universitas PGRI Semarang	4	/	/	/	/
10	Van den HeuvelPanhuizen M.	Utrecht University, Netherlands	4	/	/	/	/

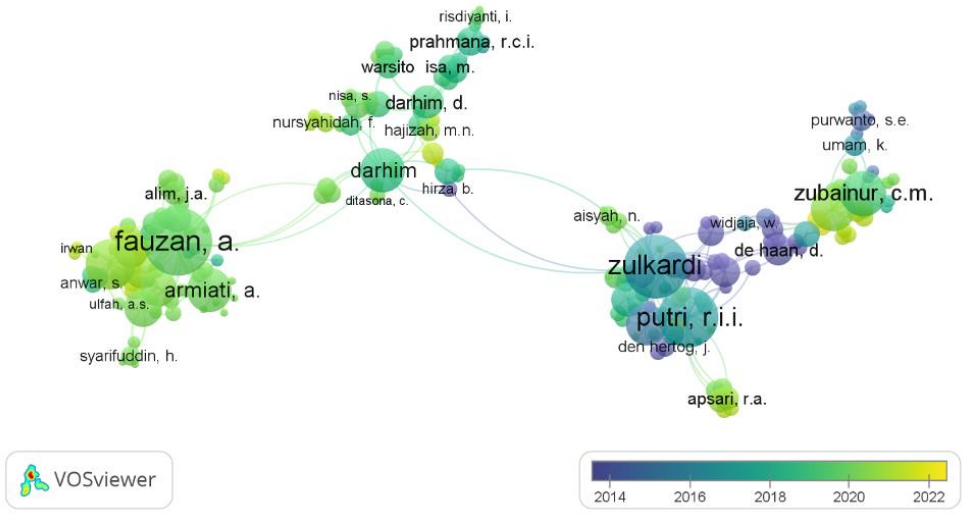
What publications, books, or conferences had the biggest influence on RME literature?

According to the quantity of research articles on RME and the number of times those papers were cited, Table 1 lists the primary sources of RME research. Journal of Physics: Conference Series, Journal on Mathematics Education, Journal of Mathematical Behavior, International Journal of Scientific and Technology Research, and Educational Studies in Mathematics round up the top five journals by the quantity of references. Additionally, there are several sources from educational studies that provided by the preceding five sources with the highest usage rates were ZDM

- International Journal on Mathematics Education, Journal of Mathematical Behavior, Educational Studies in Mathematics, Journal for Research in Mathematics Education, and International Educational Studies.

Figure 3

Co-authorship of RME-related work from 2000-2022 scientific map



What are the most crucial subjects covered in the RME research papers?

I used VOSViewer to run a joint keyword analysis to get the solution to this research inquiry. K eywords make reference to the associated documents. Each piece of writing has four to six keywords. The co-key network created from our database is depicted in Figure 7. A keyword is represented by each node. The size of the nodes represents the frequency with which the associated keyword appears in the chosen RME document. The shade denotes how recently the associated keyword was used. Figure 5 displays instances where "True mathematical education," students, mathematics teaching methods, and engineering education all occurred at the same time. The most prevalent pairs or triples of keywords can be counted because they all appear simultaneously. In particular, real math education, students (206), real math education, math teaching techniques (170 times), and real math education, engineering education (54 times) are the most prominent combined keyword pairings. The two most crucial terms are real mathematics education and math teaching techniques. We might also want to take a look at the most significant terms that have just surfaced. We take into account the yellow nodes in Figure 5 in order to overcome this issue. Recent "most requested" RME subjects include algebraic thinking and flipped classrooms Voigt et al., (2020), Apsari and Putri (2020).

Table 2

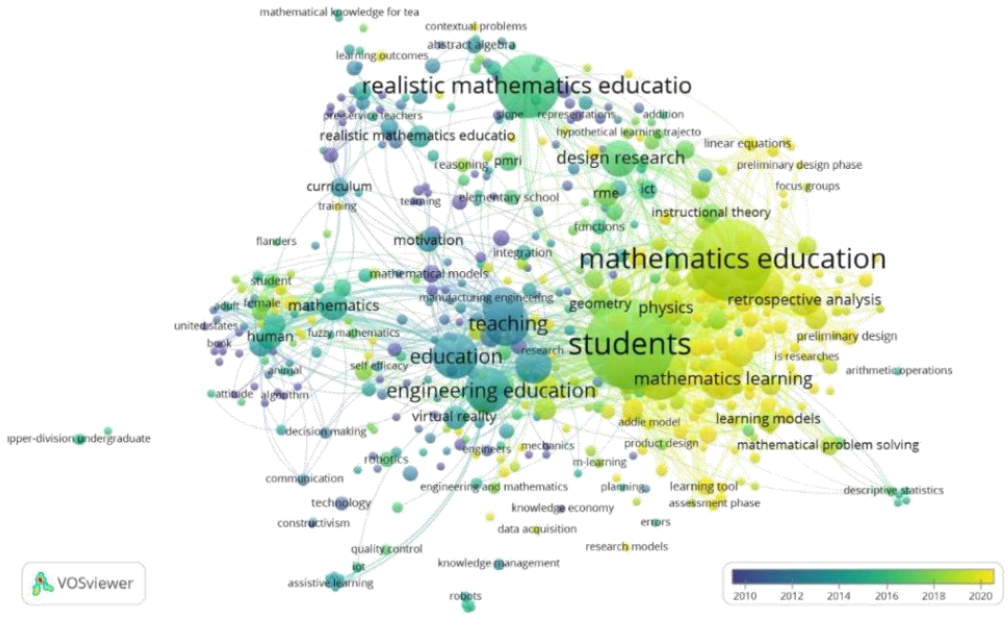
Top 5 sources based on the number of publications and their citations on RME between 2000 and 2022

Top 5 RME sources for documents				**Top 10 RME sources for quotes**			
Rating	**Source**	**Source Type**	**Documents**	**Rating**	**Source**	**Source Type**	**Documents**
1	Journal of Physics: Conference Series	Conference and work	142	1	ZDM - International Journal on Mathematics Education	Magazine	559
2	Journal on Mathematics Education	Magazine	32	2	Journal of Mathematical Behavior	Magazine	365
3	Journal of Mathematical Behavior	Magazine	18	3	Educational Studies in Mathematics	Magazine	350
4	International Journal of Scientific and Technology Research	Magazine	15	4	Journal for Research in Mathematics Education	Magazine	189
	Educational Studies in Mathematics	Magazine	11	5	International Education Studies	Magazine	114

Context Matter (Reinke and Casto, 2020), Mathematical Communication (Armiati et al., 2019), Addy (Chairil Hikayat et al., 2020), Electronic Module (Chairil Hikayat et al., 2020), the influence of culture (Revina & Leung, 2019), the pattern of numbers (Fauzan & Diana, 2020), emergent models (Rasmussen et al., 2019).

Figure 5

Co-authorship of RME-related work from 2000-2022 scientific map



Discussions

Real Mathematics Education (RME) is an innovation in mathematics education is considered a teaching method. This teaching method has been recognized by people year after year and has started to be used in their environment. In other words, RME is expanding its global reach beyond the borders of the Netherlands. In this research paper, I reviewed RME research by using bibliometric analysis methods. Let's assume, in particular, that 506 RME-related scientific studies from the Scopus database were examined with Excel and VOSViewer between 2000 and 2020. Based on the four research questions, four elements were examined: I overall size, growth trajectory, and geographic distribution; (ii) authors and research groups; (iii) sources (i.e., journals, books, conferences); and (iv) the most crucial RME research issues.

RME research has gained more attention in terms of quantity and geography in different countries around the world, among which Indonesian publications play an important role, especially those published since 2017. There is a reason why authentic mathematics education has been such a huge success in Indonesia. This accomplishment is attributable to Indonesia's successful educational innovation policy and is explicable by standardized global collaboration in instructional research and application through a number of projects over a number of years, specifically the Netherlands Program for Institutional Strengthening of Post-secondary Education and Teaching Capacity and the Pendidikan Matematika Dissemination Project (Zulkardi et al., 2020). The RME International

Master's Program, the International RME Conference, the Indonesian Context-Based Mathematics Competition, and the Math Tasks Project, as well as the RME Portal, an RME coursework for high school mathematics teachers in Southeast Asia, and the Establishment and Development of Mathematics Education Journalnal, were significant activities and outcomes that followed these projects (Zulcardi et al., 2020As a result, since 2017, the number of scholarly and organized RME case studies by Indonesian academics (published in journals with a Scopus index) has been continuously rising. Indonesia's ME innovation process is well organized, making it a great example for other nations. It is clear that Dutch academics, who established RME and whose essential ideas about this topic are used by scientists and researchers all over the world, lead the list of authors who have received the most citations. The partnership amongst previous nations in RME research is seen in the co-authorship map. Indonesia is a significant center for international collaboration in RME research, although being dominated by international networks of Dutch experts. Since RME differs and is applied very differently in the US compared to the Dutch technique, it is obvious that RME in Indonesia has been more affected by RME in the Netherlands than by RME in the US. 2020 (Webb and Frederick). The findings also demonstrate that each and every one of the RME studies that were chosen was published in a reputable journal related to mathematics education. There have been 142 articles published on RME research in The Journal of Physics: Conference Series, a journal that specialized in publishing papers linked to conferences.

RME researchers indicate a strong interest in presenting at international conferences and sharing their work with the scientific community at large. Alongside A. Irnticthleis, WaaDy, and Uitncdho-Nesian RME scientists, Ewnitahti3o2n, the second highest productive RME journalist, has managed to build their name and accomplishments in the local academic community as well as foreign connections. Additionally, RME research covers a wide range of topics, including teachers' perceptions and instructional practices, educational material (such as differential equations, number patterns, percent, square, addition, etc.), student points of view (such as creative thinking, cooperative learning, problem-solving skills, motor, and mathematical), and more (context, assessment, learning outcomes, guided reinvention, and so on). Contrary to other educational levels, elementary school pupils make up the majority of the subjects of these RME investigations. Future study opportunities in other mathematical topic areas and levels are suggested by these findings.

Conclusion

In conclusion, this research paper describes and analyzes the development, topics, and collaborative activities of research in the field of RME (real mathematical education), as shown by the total volume of literature related to RME and its temporal evolution. For the last 7-8 years, especially after 2016, the attention of those working in the field of GME Education has been getting more and more distracted.. This demonstrates the expanding social requirement for mathematicians and math teachers to stay current in their fields of study. Teaching strategies for mathematics are becoming more grounded in reality.

In addition, the Netherlands, the United States, and Indonesia were found to have the highest rates of RME adoption, according to the regional distribution of RME-related research. Many researchers have undertaken and are actively undertaking study in this topic as of the year 2000. At this moment, we can speak specifically of Indonesia. In recent years, research on novel teaching techniques has increased annually thanks to Indonesia's effective educational policy (Zulkardi, 2020). Indonesian scholars have the majority of publications in the subject of RME, despite the fact that Dutch articles are the most frequently cited. RME publications can be assigned to four main sources, the majority of which are well-known journals in education research, based on the co-citation criteria. The use of digital technologies in instruction and design-based study based on RME theory are still ongoing are topics of research. This demonstrates that in the framework of the fourth digital revolution, RME will continue to be explored and utilized in many nations. 2020 (Trung Tran).

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