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Research articles

The relationship between mathematical literacy and the realistic mathematics education approach: A systematic literature review

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Abstrak Tinjauan literatur sistematis (SLR) ini mengeksplorasi hubungan antara literasi matematika dan pendekatan Pendidikan Matematika Realistik (RME), yang menekankan penggunaan konteks dunia nyata dalam pengajaran matematika. Kajian ini mengkaji studi yang diterbitkan antara tahun 2019 dan 2024, dengan fokus pada tren, metodologi penelitian, dan efektivitas RME dalam meningkatkan literasi matematika siswa. Temuan menunjukkan bahwa RME secara signifikan meningkatkan pemahaman siswa tentang konsep matematika dan memperkuat keterampilan pemecahan masalah mereka dengan menggabungkan pengalaman belajar berbasis konteks yang praktis. Tinjauan ini juga mengidentifikasi instrumen penelitian yang sering digunakan dalam penelitian terkait RME dan menyoroti pentingnya pembelajaran kontekstual dalam mempromosikan literasi matematika. Terlepas dari tantangan yang ada, seperti kebutuhan akan desain pembelajaran yang lebih inovatif dan relevan secara kontekstual serta adaptasi RME di berbagai lingkungan pendidikan, pendekatan ini telah terbukti menjadi strategi yang efektif untuk memajukan literasi matematika siswa, berpikir kritis, dan kemampuan pemecahan masalah. Temuan-temuan ini berkontribusi pada penelitian yang terus berkembang yang mendukung pendekatan berbasis konteks dalam pendidikan matematika.

Kata kunci *Literasi matematika, Pendidikan matematika realistic, Tinjauan literatur sistematis, Pembelajaran berbasis konteks.*

Abstract This systematic literature review (SLR) explores the relationship between mathematical literacy and the Realistic Mathematics Education (RME) approach, which emphasizes the use of real-world contexts in mathematics instruction. This review was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and rigor in the selection, analysis, and synthesis of relevant studies. The review examines studies published between 2019 and 2024, focusing on trends, research methodologies, and the effectiveness of RME in enhancing students' mathematical literacy. The evidence suggests a potential relationship between the implementation of RME and students' tendencies to demonstrate a better grasp of mathematical concepts, as well as a stronger inclination toward solving problems in context-based settings. These findings, while drawn from limited and non-randomized studies, suggest that RME may be associated with more meaningful student engagement in mathematics.The review also identifies the research instruments frequently used in RME-related studies and highlights the importance of contextualized learning in promoting mathematical literacy. Despite challenges, such as the need for more innovative, contextually relevant learning designs and the adaptation of RME across various educational settings, the approach has proven to be an effective strategy for advancing students' mathematical literacy, critical thinking, and problem-solving abilities. These findings contribute to the growing body of research that advocates for context-driven approaches in mathematics education.

Keywords *Mathematical literacy, Realistic mathematics education, Systematic literature review, Context-based learning*

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Introduction

Mathematical literacy is a crucial competency that enables individuals to understand, interpret, and apply mathematical concepts in various real-life contexts. It involves not only the ability to perform calculations and logical reasoning but also skills such as problem-solving, data analysis, and data-driven decision-making (Susanta, Sumardi, Susanto, & Retnawati, 2023). This competence supports students' academic success across disciplines and is essential for navigating the demands of a complex, modern world. Mathematical literacy encompasses the ability to formulate, use, and evaluate mathematical information by understanding relevant concepts, procedures, and tools (Goos & O'Sullivan, 2023). Its goals include fostering critical thinking, enhancing collaboration, and preparing students to address real-world challenges effectively. Despite its importance, improving mathematical literacy remains a significant challenge in education. Although the focus on mathematical literacy has been longstanding, many students still struggle with understanding concepts and applying mathematics in their daily lives (Post, 2019). Global assessments, such as PISA, indicate that this issue persists. The PISA 2022 results reveal that Indonesian students scored 366 in mathematics, considerably below the global average of 575. This gap underscores the urgent need to enhance mathematical literacy as part of educational reform efforts (OECD, 2024). Consequently, this situation reveals the need for effective learning strategies to improve students' mathematical literacy across Indonesia.

The low mathematical literacy among students highlights the need for changes in learning strategies, particularly in educational contexts where mathematics is presented abstractly and disconnected from students' everyday experiences (Yusmar & Fadilah, 2023). Research indicates that one of the primary reasons for this low literacy is ineffective teaching methods. Students often find it challenging to connect mathematical concepts to real-life situations, which hinders the development of their literacy skills. To enhance students' mathematical literacy, effective learning strategies are essential (Kolar & Hodnik, 2021).

Effective learning should encourage students to think critically, solve problems, and apply mathematical concepts in various contexts. Context-based learning and problem-solving strategies have been shown to improve mathematical literacy significantly. With the right approach, students can more easily grasp and apply mathematical concepts relevant to everyday life (Ahdhianto, Marsigit, Haryanto, & Santi, 2020). Therefore, a focused learning approach is necessary to bridge this gap and help students recognize the importance of mathematics in their daily lives.

Realistic Mathematics Education (RME) is an instructional approach developed in the Netherlands, primarily by Hans Freudenthal and further elaborated by the Freudenthal Institute. At its core, RME views mathematics as a human activity, emphasizing that students should reinvent mathematical ideas through guided exploration rather than receive them passively. One of the key principles of RME is "guided reinvention," where students are encouraged to develop formal mathematical knowledge by working from informal strategies based on real-life contexts. Another principle is "didactical phenomenology," which involves selecting meaningful problems that can reveal essential mathematical structures. In RME, contexts are not merely illustrations but serve as starting points for mathematization-transforming everyday problems into mathematical models. This process fosters students' engagement, conceptual understanding, and the ability to apply mathematics in real-life situations. Through activities that involve exploration, discussion, and reflection, RME supports the development of mathematical literacy, including logical reasoning, problem-solving, and data-informed decision-making (Freudenthal,

1999; Gravemeijer, 1994; Panhuizen & Drijvers, 2020). By connecting mathematics to students' lived experiences, RME offers a meaningful learning pathway that enhances both conceptual understanding and higher-order thinking skills.

Numerous studies have explored both mathematical literacy and the RME approach as separate areas of interest. While some prior reviews have focused on either the implementation of RME (Panhuizen et al., 2020) or the development of mathematical literacy across various curricula (OECD, 2024), there remains a lack of comprehensive reviews that specifically examine the intersection between these two domains. Most existing literature tends to address RME's pedagogical aspects or analyze mathematical literacy within standardized assessments, but few systematically investigate how RME contributes to enhancing mathematical literacy. Conducting a Systematic Literature Review (SLR) is therefore essential to synthesize recent research, identify trends, evaluate methodological approaches, and reveal how RME has been linked to the development of students' mathematical literacy. This review aims to fill that gap by providing a comprehensive overview of studies published between 2019 and 2024. Moreover, an SLR can highlight underexplored areas and inform future innovations in theory and practice, particularly in optimizing the RME approach to support students' ability to reason, model, and apply mathematics in real-life contexts (Lady, Utomo, & Chikita, 2018)

A comprehensive literature review enriches our understanding and serves as a foundation for developing more effective learning strategies. This, in turn, encourages innovation and fosters the creation of learning experiences that are more relevant to students' needs (Galvis, 2018). To provide meaningful insights for educators and researchers regarding the development of mathematical literacy through the application of the RME framework, this study explores five core research questions. The first question is what trends are observable in articles concentrating on mathematical literacy through applying the RME framework from 2019 to 2024, as evidenced by journal publications? (RQ 1), which is important to identify how the field has evolved over time. The second question is among the analyzed studies, what research methodologies were employed by the authors in their examinations? (RQ 2), offering guidance for future researchers in selecting appropriate approaches. The third question is what instruments were used in the study to apply the RME approach to mathematical literacy as described in the discerning article? (RQ3) explores the instruments used in applying the RME approach to mathematical literacy, such as tests, interviews, or learning modules, providing practical references for implementation. The fourth question is how are the results of data analysis and conclusions obtained from the Research? (RQ 4), helping to uncover the effectiveness and impact of RME on mathematical literacy. Lastly, the fifth question is what is the most trending keyword in the current article, and how does it relate to the year of publication? (RQ 5), shedding light on evolving research focuses and emerging themes. These five research questions aim to contribute to the advancement of mathematics education research, particularly in the effective integration of RME to foster students' mathematical literacy.

Methods

This systematic literature review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency, rigor, and replicability in the review process. The Scopus database was used as the primary source for identifying relevant studies, as it offers extensive global coverage across disciplines and maintains high-quality indexing standards through regular curation and peer-reviewed content

(Pisani, Kourula, Kolk, & Meijer, 2017). The initial search used a combination of Boolean operators, synonyms, and wildcard terms to maximize the retrieval of relevant literature. Specifically, the search string included terms such as ("mathematical literac" OR numeracy OR "quantitative literac") AND ("realistic mathematics education" OR RME OR "context-based mathemat") to capture a broad range of studies related to mathematical literacy and the RME approach.

In addition to the content-based inclusion criteria, a bibliometric analysis was conducted using VOSviewer software to complement the qualitative synthesis. This analysis aimed to address Research Question 5 by identifying keyword trends, thematic clusters, and the temporal evolution of research themes within the selected studies. Metadata from the articles such as titles, abstracts, and keywords were extracted and imported into VOSviewer to generate co-occurrence maps and trend visualizations, offering deeper insights into emerging topics and interrelated concepts in mathematics education research.

Data collection

Eligibility criteria

Table 1 shows the inclusion and exclusion criteria applied in this study: language, database, subject, content relevance, and publication accessibility. To ensure the systematic nature of this research, only articles that are publicly available and relevant to both mathematical literacy and the RME approach are included. The articles must be written in English to ensure broad accessibility and understanding. Furthermore, the studies must be found in a single designated academic database to maintain consistency and traceability. The subject of the reviewed studies must lie within the educational field, especially on the integration of mathematical literacy and RME. Articles must explicitly combine both concepts in their analysis or discussion. Conversely, documents that are unavailable to the public, published outside the year range 2020 to 2024, or that do not address both key themes (mathematical literacy and RME), as well as duplicates from other databases, are excluded from the review process.

Data and search terms

The primary strategy for identifying Effect Sizes within academic databases is the careful selection of keywords. It is suggested that keywords be thoughtfully chosen to include terms that yield the desired information, along with alternative terminologies to enrich the dataset. Consequently, employing a strategic combination of keywords alongside Boolean operators ('AND', 'OR', and 'NOT') is recommended.

Table 1. Eligibility criteria

Criterion	Inclusion	Exclusion
Language	English	Other than English
Database	Cataloged in six designated academic databases	Articles duplicated across multiple databases
Subject	Topics within the educational field	Topics unrelated to education
Content Relevance	Combine discussions on mathematical literacy and RME	Address only mathematical literacy or only RME
Publication Status	Publicly available, published between 2020 and 2024	Not publicly available or published outside 2019–2024
Document Type	Research articles	Non-journal articles (e.g., reviews, editorials, or opinion pieces)

Identification

In this investigation, the author sourced published articles from the Scopus-indexed database using an initial search string ("Mathematical Literacy" AND RME). Recognizing that this combination might be too narrow, we expanded our search strategy by incorporating relevant synonyms and wildcard terms such as ("mathematical literacy" OR "quantitative literacy" OR "numeracy") AND ("realistic mathematics education" OR "RME" OR "context-based mathematics") to ensure broader coverage of the literature. This refined search approach yielded a total of 10,129 research publications released between 2019 and 2024. To ensure a comprehensive and representative review, the author further curated scholarly articles from additional databases, including ResearchGate, ERIC, ProQuest, Emerald Insight, Taylor & Francis Online, and EBSCOhost. This strategy allowed us to identify and include a diverse range of studies relevant to the intersection of RME and mathematical literacy.

Screening

The findings from the search conducted across the databases specified in the study are summarized in Table 1. A total of 9 studies were identified after excluding 571 studies that did not meet the established criteria. Each of the 9 studies was analyzed individually to extract detailed information. A systematic methodology was used to determine the thematic significance and interpretation of the gathered data. While reviewing the selected articles, the researchers kept detailed anecdotal records and examined the studies on mathematical literacy and RME multiple times to assess the relevance of the themes. The PRISMA sequential approach employed in the systematic evaluation of the included research is illustrated in Figure 1.

Finally, in response to the third research question of this systematic review, we sought to identify the methodological tools used by researchers to measure children's mathematical skills. Various researchers have reported that there are limited instruments available to assess young children's mathematical skills and competencies. After completing this process, 15 eligible studies were selected for inclusion in the current review.

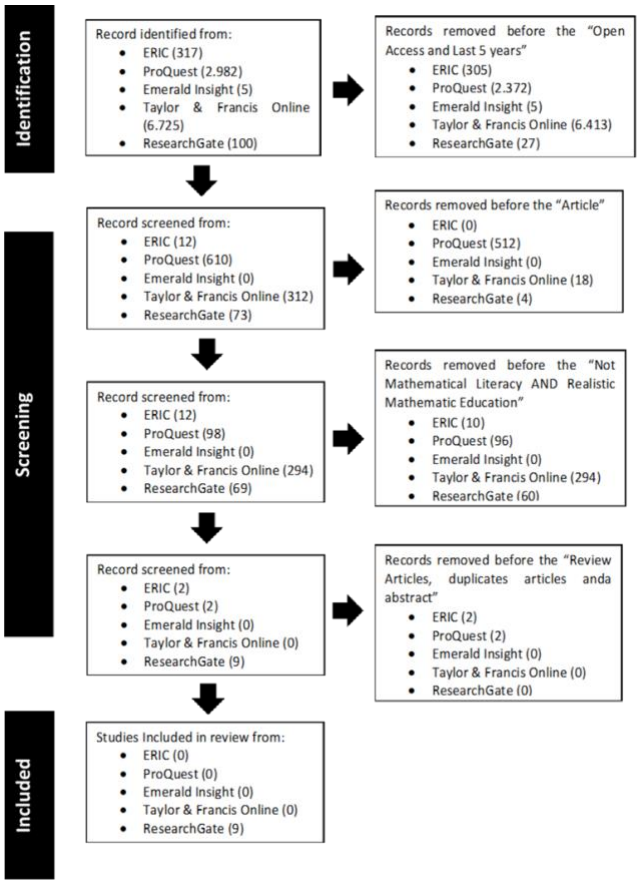


Figure 1. Prisma Flow Diagram for Data of Collection Process

Findings

The nine articles that passed the screening process were then reviewed to answer the research questions. Notably, all of the included studies were conducted in Indonesia. While this provides valuable insights into how the RME approach has been applied and studied within the Indonesian educational context, it also presents a significant limitation. The concentration of studies in a single country restricts the generalizability of the findings to broader or more diverse educational systems. Cultural, curricular, and pedagogical factors unique to Indonesia may influence the design and outcomes of these studies, which may not be directly transferable to other regions or international settings. Therefore, readers should interpret the results of this review with caution and consider them as context-specific insights rather than universal trends. Further research from a wider range of countries is needed to validate and expand the understanding of the relationship between RME and mathematical literacy across diverse educational contexts.

RQ 1: What trends are observable in articles concentrating on mathematical literacy through applying the RME framework from 2019 to 2024, as evidenced by journal publications?
Figure 2 illustrates the publication trends for nine studies exploring the application of the RME (RME) approach in enhancing students' mathematical literacy between 2019 and 2024. The articles were grouped based on their year of publication to provide a clearer perspective on developing this research focus.

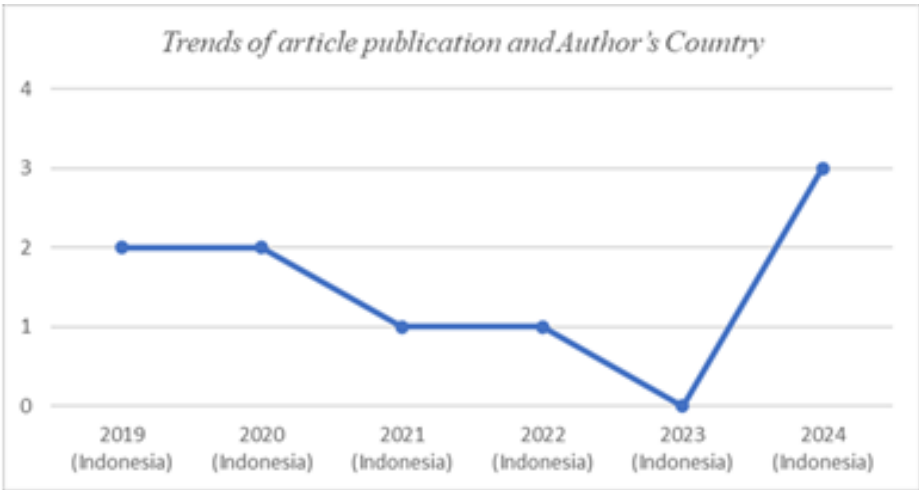


Figure 2. Trends in research publications on Mathematical literacy and RME in mathematics education.

From 2019 to 2022, the number of publications remained relatively stable, indicating a steady but modest interest in investigating how RME could be integrated into mathematics instruction to foster mathematical literacy. In detail, two articles were published in 2019 and 2020, while a slight decline was observed in 2021 and 2022, with only one article published each year. This trend suggests that while the interest was consistent, it did not reach a broader research audience.

Interestingly, no recorded publications in 2023 related to the implementation of RME for mathematical literacy which might indicate a temporary shift in research priorities or challenges faced by researchers during that period. However, this trend shifted significantly in 2024, when there was a marked increase with three articles published. This surge highlights a renewed interest in the topic, potentially driven by a rising focus on integrating technology, such as GeoGebra, into RME-based teaching practices.

Overall, the results reflect an increasing recognition of the importance of RME in developing mathematical literacy, especially in recent years. The notable rise in publications in 2024 suggests that the topic is gaining traction within the research community, aligning with broader educational trends emphasizing contextual and interactive learning approaches. The absence of publications in 2023 appears to be a temporary anomaly rather than an indicator of diminishing interest, as evidenced by the rapid growth observed in the subsequent year. This pattern reinforces the potential of RME as a promising pedagogical strategy in mathematics education and underscores the ongoing efforts of researchers to explore its effectiveness.

A careful examination of the nine articles reviewed on mathematical literacy and RME (RME) revealed that all contributions originated from Indonesia, as seen in Figure 2, thus highlighting Indonesia's important role in developing this academic field. Indonesia's urgent imperative necessitates this focus to alleviate ongoing challenges in students' mathematical abilities, as evidenced by inadequate results in international assessments such as the Programme for International Student Assessment (PISA) (OECD, 2024). In reaction to this challenge, the Indonesian government has implemented significant educational reforms, including the Minimum Competency Assessment (MCA), which emphasizes enhancing mathematical literacy (Kusmaryono & Kusumaningsih, 2023). Given its emphasis on student-centered pedagogical

approaches and practical application, RME is congruent with these reforms, establishing it as a primary interest for educational researchers.

Furthermore, a notable catalyst for this discourse is the incorporation of RME into Indonesia's educational policies and curricular frameworks. The Ministry of Education vigorously promotes the integration of innovative pedagogical techniques, including RME, to modernize mathematical education and cultivate critical thinking and problem-solving skills among students (Astuti, Gunarhadi, & Mintasih, 2020). This policy initiative has prompted scholars to investigate and validate the effectiveness of RME, leading to a burgeoning body of academic literature in this domain (Panhuizen et al., 2020). In addition, Indonesia's dynamic academic environment and strong governmental support for educational Research have fostered a favorable atmosphere for exploring pedagogical strategies such as RME.

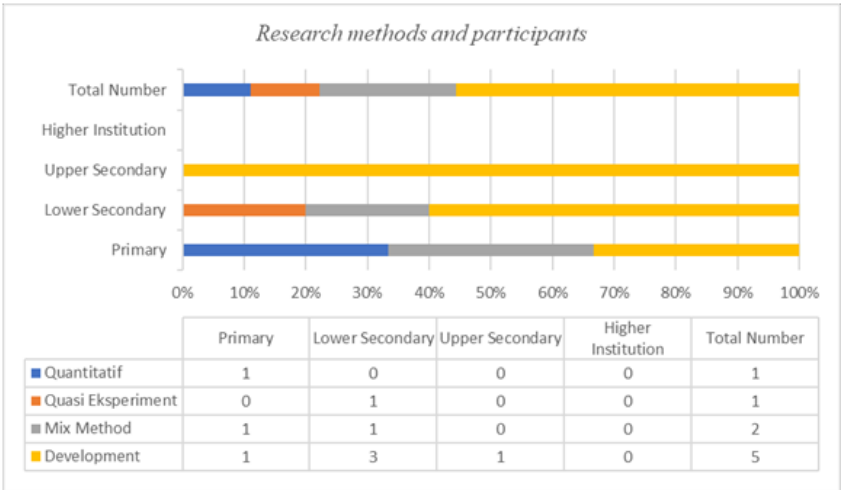
The increasing prominence of RME in Indonesia also reflects the nation's dedication to reforming its educational system to meet international standards while concurrently addressing its unique challenges. As mathematical literacy assumes critical significance in the contemporary, rapidly changing landscape, Indonesia's focus on RME positions it as a leader in pioneering strategies to improve student achievement (Gravemeijer & Stephan, 2002). These essential factors clarify why RME and mathematical literacy have emerged as focal topics of investigation in Indonesia, establishing the country as a significant contributor to this academic discipline.

RQ 2: Among the analyzed studies, what research methodologies were employed by the authors in their examinations?

Different research methods, such as quantitative, quasi-experimental, mixed, and developmental research methods, are used to answer the third research question through data collection and analysis. As shown in Figure 3, among the 9 selected papers, at the Primary level, there are three research methods with an even distribution. Quantitative, mixed method and development methods had one article out of three, so the percentage for each method was 33.33%. At the Lower Secondary level, five research articles used three different methods. Quasi-experiment and mixed methods were used in one article each, with a percentage of 20% for each method. Meanwhile, the development method was used in three articles, resulting in a dominant percentage of 60%. At the upper secondary level, only one research article fully used the development method, with a percentage of 100%. No research articles were found at the higher institution level, so all methods had a percentage of 0%. This distribution shows the dominance of developmental methods at higher education levels.

For example, Research conducted by Wijaya (2015) used a design-based method involving high school grade X students in the school year and mathematics teachers who taught in the class to evaluate the effectiveness of RME-based learning on System of Linear Equations Three Variables (SLETV) material. The effectiveness was assessed from five aspects: the quality of teachers' learning management, students' activeness, students' positive responses, the achievement of classical learning completeness, and the improvement of mathematical literacy (Deda, Laja, & Talan, 2024). Learning tools in lesson plans, worksheets, and Mathematics Literacy Tests (MLT) were developed using the Plomp model, which includes preliminary research, prototyping, and assessment stages. The instrument's validity, practicality, and effectiveness were tested through expert validation, observation, student questionnaires, and literacy tests (Nugroho, Wijaya, & Suminar, 2023). The results show that the developed learning

tools meet high-quality criteria, and their implementation significantly improves students' mathematical literacy. These findings confirm the relevance of the RME approach in creating innovative learning that supports 21st-century mathematical skills (Lee & Paul, 2023). Overall, this is the only article that explores studies related to mathematical literacy and the RME approach at the high school level.



	Primary	Lower Secondary	Upper Secondary	Higher Institution	Total Number
Quantitatif	1	0	0	0	1
Quasi Eksperiment	0	1	0	0	1
Mix Method	1	1	0	0	2
Development	1	3	1	0	5

Figure 3. Data based on research method

Two mixed-methods case studies out of the nine available articles were at the junior secondary and primary education levels, one of which was conducted by Purwanti et al. (2019) at the primary education level. This study used mixed methods (qualitative and quantitative) with a concurrent triangulation approach to explore the mathematical literacy skills of fifth-grade students of the Islamic Elementary School in Ngaliyan, Semarang. This method provided more comprehensive, valid, and objective results. The research subjects involved 58 students, 31 boys and 27 girls. Data collection was conducted through observation, tests, and interviews, with data analysis using data reduction, data presentation, and conclusion-drawing techniques. Data credibility was guaranteed through validity criteria such as transferability, dependability, and confirmability. The results showed that students' mathematical literacy was in the low category. In-depth interviews revealed that students are not yet familiar with mathematical literacy activities in daily learning. The findings highlight the importance of mathematical literacy habituation to improve students' ability to understand and solve mathematical problems contextually, which is relevant to modern learning challenges.

The only article that used the quasi-experiment method with a non-equivalent control group design which provides the advantage of testing cause-and-effect relationships more specifically in a real environment. In this study by Umbara & Nuraeni (2019), the application of RME learning based on Adobe Flash Professional CS6 compared to conventional learning in class VIII students of Junior High School resulted in applicable contextual insights. The results showed a significant improvement in the mathematical literacy skills of students who followed this technology-based learning, possibly triggered by a focus on self-regulated learning (Ali & Wardat, 2024). The main advantage of the quasi-experiment method is its ability to be applied in established classrooms, making the results more relevant to real situations. However, limitations such as the lack of full control over external variables remain challenging, which may affect the study's internal validity (Cohen, Manion, & Morrison, 2011). Nonetheless, the results

of this study enrich the understanding of the effectiveness of technology-based learning in supporting mathematical literacy, highlighting the potential of integrating technology and pedagogical approaches in improving student learning outcomes.

Finally, the only article that uses quantitative methods is the study conducted by Fauzan et al. (2024); the quantitative method used in this article highlights its ability to produce valid and reliable numerical data, utilizing statistical analysis to identify patterns and relationships between variables. With a modified pretest-posttest design, this study allows for an in-depth evaluation of the effectiveness of RME learning in improving primary school students' literacy and numeracy (Post, 2019). The advantage of this approach is its ability to generalize results to a wider population, providing a robust picture of trends or changes due to the intervention. However, while this method can significantly improve students' abilities, a key limitation lies in the lack of exploration of the influence of social or emotional contexts that might affect outcomes (Johnson & Christensen, 2024). The result that teacher experience does not affect students' literacy and numeracy is an interesting finding emphasizing the focus on learning methods rather than individual teacher variables (Ali & Wardat, 2024). This article demonstrates the power of quantitative methods in providing evidence-based data supporting education decisions.

RQ 3: What instruments were used in the study to apply the RME approach to mathematical literacy as described in the discerning article?

Table 2 presents the research instruments used in various studies investigating the integration of Realistic Mathematics Education (RME) and mathematical literacy. The instruments identified range from mathematical literacy tests, questionnaires, interviews, to expert validations and observation sheets. These tools were employed to measure diverse aspects such as students' mathematical abilities, attitudes, learning experiences, and the effectiveness or practicality of developed models or learning aids. The variety of instruments reflects the comprehensive approach taken by researchers to evaluate both the cognitive and affective outcomes of implementing RME in mathematics education.

Table 2. Research instrument

Citation	*Article title*	*Research instrument*
Rusdi et al., (2020)	Designing Mathematics Learning Models Based on RME and Literacy	This study used several instruments to evaluate the RME-based mathematics learning model. Questionnaires and interviews were used to understand students' and teachers' learning styles and needs. Expert validation was conducted to check the suitability of the prototype. Evaluation is done through self-evaluation, individual evaluation, small group evaluation, and field tests to ensure the model is effective and applicable.
Lubis et al. (2024)	Development of A Learning Model Based on RME for Improving Mathematical Literacy Skills and	This Research used several instruments to evaluate the RME (RME)-based learning model: validation sheets to assess the model's validity, lesson plans, student worksheets, mathematical literacy tests, and Mathematical disposition questionnaires. In addition, a mathematical literacy test was used to measure

	Students' Mathematical Disposition	students' ability to apply mathematical concepts and a mathematical disposition questionnaire was used to assess students' attitudes toward mathematics. These instruments ensure the developed learning model is valid, practical, and effective.
Sari et al. (2023)	Development of E-Worksheet Based on RME to Support Mathematical Literacy Skills of Junior High School Students	This study used several instruments to evaluate the developed e-worksheet. Material and media experts used validation questionnaires to assess validity based on content, construct, language, appearance, and software engineering. The student response questionnaire measured the practicality of the e-worksheet in terms of facilities, motivation, attractiveness, and benefits. In addition, open-ended interviews were conducted to find out students' experiences, and observation was used to record students' responses when working on the e-worksheet at the one-to-one and small group stages. These instruments ensure the validity and practicality of the RME-based e-worksheet.
Wijaya et al., (2021)	Development of Realistic Mathematics Learning Tools to Improve Students' Mathematical Literacy Ability	This study used several instruments: validation sheets to assess the quality of learning instruments (Lesson plan, student worksheet, and test), observation sheets to monitor teacher and student activities, and questionnaires to determine student responses. In addition, the Mathematical Literacy Test (TLM) was used as a pre-test and post-test to measure students' mathematical literacy skills and their improvement using the N-Gain formula.
Umbara & Nuraeni, (2019)	Implementation of Realistic Mathematics Education Based on Adobe Flash Professional Cs6 to Improve Mathematical Literacy	This study used mathematical literacy tests to measure students' abilities before and after learning and assessment questionnaires to assess students' understanding of mathematical concepts and their ability to apply them. The research design used an unequal control group, where one group received RME (RME) based learning with Adobe Flash Professional CS6, while the other group used conventional learning. Test results and questionnaires were analyzed to compare the effectiveness of the two learning methods.
Maslihah et al., (2021)	Increasing Mathematical Literacy Ability and Learning Independence Through Problem-Based Learning	This study used three main instruments: a written test to assess mathematical literacy skills, a questionnaire to measure learning independence, and interviews to deepen the analysis of the test and questionnaire results.

	Model with Realistic Mathematics Education Approach	
Purwanti et al., (2019)	Mathematical Literacy Ability with Realistic Mathematics Education (RME) Approach in Fifth-Grade Students	This study used three main instruments: observation to observe the learning process and students' activities, written tests to measure mathematical literacy skills based on various indicators, and interviews to explore the test results and understand students' obstacles and problem-solving strategies. These three instruments were used to evaluate the effectiveness of the RME (RME) approach in improving students' mathematical literacy.
Fauzan et al., (2024)	Realistic Mathematics Education (RME) to Improve Literacy and Numeracy Skills of Elementary School Students Based on Teachers' Experience	This study used three main instruments: observation to observe the learning process and students' activities, written tests to measure mathematical literacy skills based on various indicators, and interviews to explore the test results and understand students' obstacles and problem-solving strategies. These three instruments were used to evaluate the effectiveness of the RME (RME) approach in improving students' mathematical literacy.
Nurmasari et al., (2023)	Realistic Mathematics Engineering for Improving Elementary School Students' Mathematical Literacy	This study used several instruments, namely mathematical literacy tests to measure students' abilities before and after learning, questionnaires to assess the model's practicality, and expert validation to ensure the quality of the instruments. Group discussion (FGD) was conducted with teachers and observers to improve the model, while statistical analysis was used to evaluate the test results. All these instruments aim to assess the effectiveness of the Realistic Mathematics Engineering (RMEng) learning model in improving elementary students' mathematical literacy.

Most studies use structured instruments to assess students' mathematical literacy skills, one of which is the Test of Mathematical Literacy (TLM), which is used in six articles. This test serves to measure students' learning outcomes before and after the application of the learning method. In addition, several articles focusing on developing learning models and teaching aids, such as Lesson Plans, Student Worksheets, and RME-based E-Worksheets, are often used to support a more contextualized and practical learning process.

Mixed-method studies on Problem-Based Learning (PBL) with an RME approach use mathematical literacy tests, questionnaires, and interviews to understand students' learning experiences. Observations and interviews further explore student learning dynamics, as seen in Research on improving fifth graders' mathematical literacy skills (Purwanti et al., 2019). Overall, the instruments used in this Research varied according to the focus of each study. However, the main instruments used were literacy and numeracy tests, accompanied by learning aids such as

lesson plans, worksheets, e-worksheets, and mathematics disposition questionnaires (Sari et al., 2023). This shows that the instruments applied in these studies are comprehensive, including objective measurement tools and instruments that allow for a deeper exploration of students' experiences and perceptions.

RQ 4: How are the results of data analysis and conclusions obtained from the Research?
The analysis of the nine articles examined in Table 2 shows that the RME approach significantly improves students' mathematical literacy skills. Many articles reveal that RME-based learning models effectively improve mathematical literacy skills in conventional learning and those involving technology, such as Adobe Flash Professional.
Some studies show that RME learning models meet the validity, practicality, and effectiveness standards and can improve students' mathematical disposition. In addition, using learning aids such as lesson plans, worksheets, and e-worksheets based on RME is proven to support the development of students' mathematical literacy skills at various levels of education, from elementary to junior high school.

However, some studies also identified challenges, such as in a study involving grade V students with low mathematical literacy test results and a lack of mathematical literacy habituation in their learning. In contrast, studies using a mixed-methods approach, such as in the RME-based Problem-Based Learning (PBL) model, showed that students who followed this model had improved mathematical literacy and learning independence compared to the conventional model.

Overall, the results of this study show that the RME approach, both through the model and the learning tools developed, contributes positively to improving students' mathematical literacy and numeracy skills. However, some challenges with the application of habituation and consistent methods still need further attention.

RQ 5: What is the most trending keyword in the current article, and how does it relate to the year of publication?
Findings derived from visualizations using VOSViewer indicate that "mathematical literacy" occupies an important position in relevant academic investigations, closely linked to concepts such as RME (RME), realistic mathematics learning, and primary education. These terms show significant interconnectivity, underscoring the critical significance of mathematical literacy as an increasingly relevant area of Research. Furthermore, the visualization explains that RME methodologies and engineering design processes are emerging as contemporary trends in the domain of mathematical literacy, as evidenced by their representation in yellow on the temporal graph. This observation suggests a new research paradigm incorporating contextual methodologies and STEM integration in mathematics education.

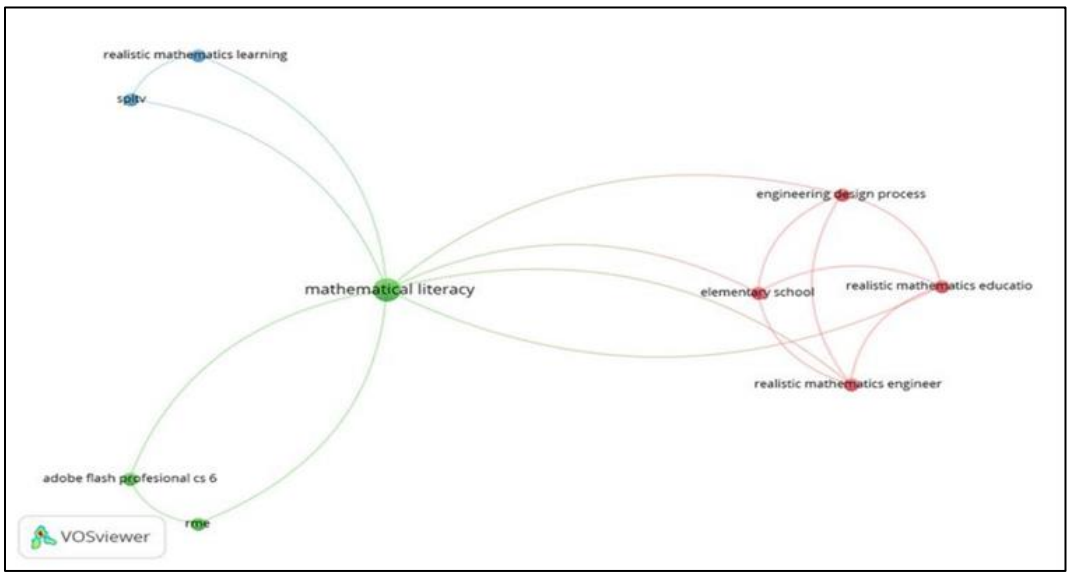


Figure 4. VOSviewer keyword cluster map for the studies (Source: Authors' elaboration, using VOSviewer software)

More historical presence in the literature (denoted in dark blue), yet they are no longer prevailing trends in current discourse. The correlation between mathematical literacy and the primary education context also highlights a focused interest in the practical application of literacy at the foundational stage of learning. In summary, the prevailing trends indicate a shift towards adopting contextualized approaches such as RME and integrating engineering design processes in the domain of mathematical literacy, especially at the primary education level.

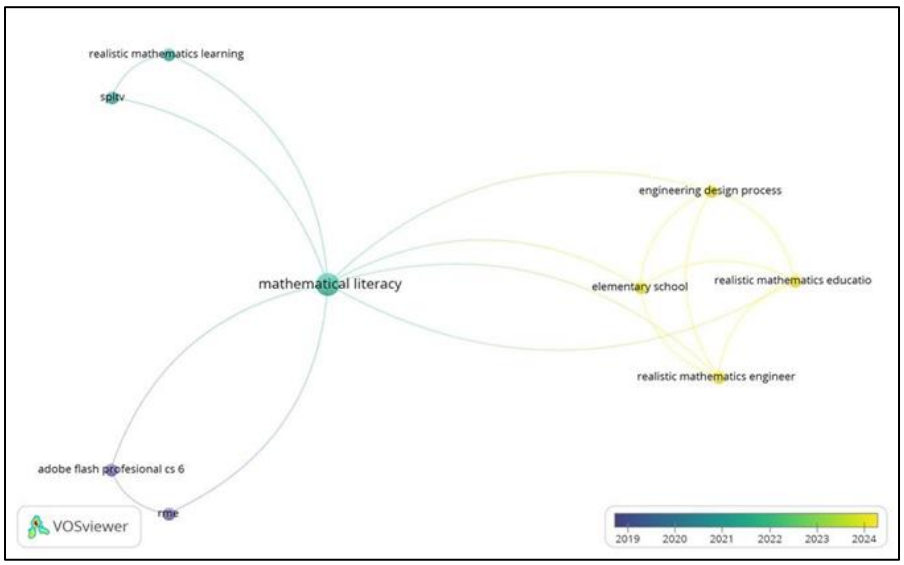


Figure 5. Evolution of the keywords in the studies by year (Source: Authors' elaboration, using VOSviewer software)

Discussion

The findings of this study highlight the significant relationship between mathematical literacy and the RME approach. Mathematical literacy, defined as the ability to apply mathematical knowledge effectively in various real-world contexts, aligns closely with the core principles of RME, which emphasize meaningful, context-based learning (Goos & O'Sullivan,

2023). By integrating real-life scenarios into the learning process, RME facilitates the development of students' ability to reason, model, and solve mathematical problems within authentic settings (Purwanti et al., 2019). This approach strengthens their capacity to connect abstract mathematical concepts and practical applications, ultimately enhancing their mathematical literacy.

While the findings of this review underscore the alignment between RME and the development of mathematical literacy, it is important to acknowledge that the reviewed studies were conducted exclusively within the Indonesian educational context. Cultural factors, curriculum structure, teacher training practices, and classroom dynamics in Indonesia may influence how RME is designed and implemented, thus affecting its outcomes. As such, the results of this review may not be universally generalizable (Rahayu et al., 2023). Further cross-cultural and cross-country studies are needed to examine the transferability of RME principles to different educational systems and sociocultural settings. Replicating similar investigations in varied international contexts would contribute to a more comprehensive understanding of how RME fosters mathematical literacy across diverse populations.

Despite the insights gained, this study has several limitations. First, the review relied heavily on studies published in the English and Indonesian languages, potentially introducing language bias by excluding relevant research published in other languages. Second, the relatively small number of included articles (n = 9) may limit the scope and robustness of the conclusions. Third, the review did not incorporate grey literature, such as theses, conference papers, or government reports, which may contain valuable findings on the topic. Additionally, the exclusive reliance on Scopus-indexed and selected academic databases may result in publication bias, as studies with statistically significant or positive results are more likely to be published in indexed journals. Finally, although a systematic approach was followed, the subjectivity involved in article selection and interpretation could also influence the outcomes. A broader and more inclusive search strategy in future research could help mitigate these limitations and strengthen the evidence base.

One of the fundamental ways RME contributes to mathematical literacy is through using contextual problems as a starting point for learning. Unlike traditional approaches that often present mathematics as a series of abstract formulas and procedures, RME introduces mathematical concepts through real-world situations that are familiar and relevant to students (Palinussa, 2020). This method encourages active problem-solving and critical thinking, enabling students to understand the utility of mathematics beyond the classroom. For example, Research by Gravemeijer & Stephan (2002) demonstrated that students exposed to RME could better apply mathematical concepts in everyday situations than those taught through conventional methods. Their ability to interpret, analyze, and solve problems using mathematical reasoning improved significantly, underscoring the effectiveness of RME in fostering mathematical literacy.

Furthermore, the stepwise progression inherent in RME moving from concrete experiences to more abstract mathematical representations is crucial in enhancing students' conceptual understanding (Freudenthal, 1999). Students gradually build a deeper comprehension of mathematical structures using models, diagrams, and interactive discussions, making it easier to generalize and transfer knowledge to new situations (Ahdhianto et al., 2020). A study by Wijaya et al. (2021) highlighted that students who engaged with mathematical models in RME were more proficient in recognizing patterns and relationships within mathematical problems, reinforcing their ability to navigate complex problem-solving tasks.

In addition to fostering problem-solving skills, RME enhances students' ability to communicate mathematical ideas effectively. The emphasis on discussion, collaboration, and argumentation within RME encourages students to articulate their reasoning, justify their approaches, and critique different problem-solving strategies (Pashkova, Palahniuk, & Matokhniuk, 2021). This process is essential for developing mathematical literacy, enabling students to engage with mathematics as a dynamic and applicable discipline. Research by Sari et al. (2023) found that students in RME-based classrooms demonstrated improved mathematical discourse skills, allowing them to construct logical arguments and make informed decisions using quantitative information.

Another significant aspect of the relationship between mathematical literacy and RME is the role of teachers in facilitating an inquiry-driven learning environment. Effective implementation of RME requires educators to design rich, meaningful contexts that stimulate exploration and discovery (Fauzan et al., 2024). Studies such as that by Lady et al. (2018) emphasize that teachers who guide students in making sense of mathematical problems rather than merely providing procedural instructions contribute to deeper mathematical understanding and literacy. This approach ensures that students do not merely memorize formulas but develop a genuine appreciation for mathematical reasoning.

Despite the clear advantages of RME in enhancing mathematical literacy, its implementation presents certain challenges. One of the primary obstacles is the time and effort required to develop high-quality contextual problems that align with curriculum objectives (Budiarto & Wijayanti, 2021). Additionally, not all mathematical topics lend themselves easily to real-world contextualization, necessitating innovative instructional strategies. Teachers must also be adequately trained to effectively facilitate student-centered discussions and inquiry-based learning (Wijaya, 2015). Addressing these challenges requires ongoing professional development and institutional support to ensure the successful adoption of RME across different educational settings.

Looking ahead, further research is needed to explore the long-term impact of RME on mathematical literacy across diverse student populations and educational levels. Additionally, integrating technology into RME-based instruction, as Palinussa (2020) suggested, could provide new opportunities to enhance students' engagement and understanding through interactive simulations and digital tools. By continually refining and expanding the application of RME, educators can further strengthen students' mathematical literacy, preparing them to apply mathematical thinking in an increasingly complex and data-driven world.

Conclusion

The RME approach is a powerful framework for developing mathematical literacy by bridging the gap between abstract mathematics and real-world problem-solving. Its emphasis on contextual learning, model-based reasoning, and collaborative inquiry equips students with the necessary skills to navigate mathematical challenges with confidence and competence. As education systems strive to cultivate mathematically literate individuals, integrating RME into mathematics instruction remains a promising and transformative approach.

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