

How is the Implementation of Realistic Mathematics Education on Mathematical Literacy Skills? A Systematic Literature Review

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Article received: 24-05-2024, revision: 06-06-2024, published: 30-07-2024

Abstrak

Penelitian ini bertujuan untuk mengkaji penerapan pendidikan matematika realistik (RME) dalam meningkatkan keterampilan literasi matematika dan mengidentifikasi kesenjangan serta rekomendasi untuk penelitian lebih lanjut dalam meningkatkan keterampilan literasi matematika. Melalui metode tinjauan pustaka sistematis, penelitian ini mengkaji 18 artikel relevan dari Scopus yang diambil dalam periode 2018-2023 menggunakan aplikasi Publish or Perish. Analisis data dalam penelitian ini dilakukan menggunakan kerangka kerja PIECES (Planning, Identifying, Evaluating, Collecting/Elaborating, Explaining, dan Summarizing). Hasil analisis menunjukkan bahwa RME dapat secara signifikan meningkatkan literasi matematika siswa dengan mendorong keterlibatan aktif, pemahaman yang mendalam, dan transferabilitas pengetahuan dalam berbagai konteks. Selain itu, penelitian ini menyoroti kesenjangan penelitian dan menawarkan wawasan untuk penelitian di masa mendatang. Temuan-temuan ini memberikan kontribusi penting bagi pengembangan metode pembelajaran matematika berbasis literasi di berbagai tingkat pendidikan.

Kata Kunci: Penerapan pembelajaran matematika; Literasi matematika; Pendidikan matematika realistik; Tinjauan pustaka sistematis; PMRI.

Abstract

This research aims to examine the application of realistic mathematics education (RME) in improving mathematical literacy skills and identify gaps and recommendations for further research in improving mathematical literacy skills. Through a systematic literature review method, this research examines 18 relevant articles from Scopus taken in the 2018-2023 period using the Publish or Perish application. Data analysis in this research was carried out using the PIECES framework (Planning, Identifying, Evaluating, Collecting/Elaborating, Explaining, and Summarizing). The analysis results show that RME can significantly improve students' mathematical literacy by encouraging active engagement, deep understanding, and transferability of knowledge in various contexts. Additionally, this study highlights research gaps and offers insights for future research. These findings provide an important contribution to the development of literacy-based mathematics learning methods at various levels of education.

Keywords: Application of mathematics learning; Mathematical literacy; Realistic mathematics education; Systematic literature review; PMRI.

I. INTRODUCTION

The Realistic Mathematics Education (RME) approach is present as one of the most influential learning approaches in the world of mathematics education with the characteristic of applying learning content to real life which is very close to students' daily lives (Sitorus & Masrayati, 2016; Sumirattana et al., 2017). One of the benefits of the RME approach is strengthening mathematical literacy skills by presenting mathematical concepts in real-world contexts, so that students not only understand these concepts theoretically, but are also able to apply them in everyday life (Paolucci & Stepp, 2021; Haas et al., 2023). The success of implementing RME learning depends on how teachers and students understand and apply the learning principles in this approach. Gravenmeijer (1994) explains that there are 3 principles in learning mathematics with the RME approach, namely the principle of guided reinvention, didactic phenomenology and the self-development model.

The Organization for Corporations and Economic Development (OECD, 2019) states that mathematical literacy is seen as an individual's ability to understand the role of mathematics in life, make it meaningful, and be able to apply mathematics in the process of meeting individual life needs both now and in the future. Several competencies required in mathematical literacy are described in (PISA) which is under the auspices of the OECD including, mathematical thinking and reasoning; Mathematical Argumentation; Mathematical Communication; Modeling;

Solution to problem; Representation; Symbol; Tools and Technology (Ojose, 2011).

In this increasingly connected and complex era, mathematical literacy is an increasingly important skill. Mathematical literacy skills are skills used in defining the competencies needed to meet the various demands of modern society (Bolstad, 2023). Knowing and understanding the role of mathematics in the context of life that is close to everyday life is important for every individual to be able to accurately analyze, through the process of evaluating and considering how to implement mathematics in meeting various needs to become constructive, caring and cooperative members of society (Rizki & Priatna, 2019).

However, the importance of mathematical literacy skills is still not in accordance with its implementation. Based on many studies, it has been found that in several cities in Indonesia students still have low abilities in terms of mathematical literacy skills (Tokada et al., 2017). Student learning outcomes in mathematical literacy also do not provide maximum results (Suharta & Suarjana, 2018). Apart from that, Indonesia's mathematical literacy skills are also classified as poor in PISA 2018 with a score of 379, far below the OECD average score of 489 (OECD, 2019). Some evidence is shown to clarify the factors that influence students' mathematical literacy abilities, namely students are less able to solve context-based mathematical problems (Afriansyah & Arwadi, 2021); teachers only provide material and routine practice questions at a low level (Susanti et

al., 2023); teachers' difficulties in designing mathematics tasks such as PISA (Mutiakandi & Sari, 2024); and lack of learning resources provided (Nusantara et al., 2020).

Several studies have been conducted to explore the effectiveness of RME in improving mathematical literacy such as several articles that will be discussed in this review. However, the results of these studies vary and there are still questions about the extent to which the implementation of RME can have a significant impact on mathematical literacy. Therefore, this study aims to conduct a systematic review of the literature on the implementation of RME in improving mathematical literacy skills. This study will not only present a summary of the findings of existing studies but also identify challenges and opportunities that may exist in the implementation of RME in various learning contexts. Through this review, it is hoped that deeper insights will be found regarding the effectiveness of RME and practical recommendations for teachers and policy makers in optimizing the implementation of RME to improve students' mathematical literacy.

The novelty of this study lies in conducting a systematic review of the Realistic Mathematics Education (RME) approach, with a specific focus on its implementation and impact on enhancing mathematical literacy skills. While previous studies have explored the potential benefits of RME, this research provides a comprehensive synthesis of findings, identifies challenges and opportunities in applying RME across various learning

contexts, and offers practical recommendations for educators and policymakers. By addressing gaps in understanding the effectiveness of RME, this study aims to contribute deeper insights and actionable strategies to optimize the implementation of RME for improving students' mathematical literacy in an increasingly interconnected and complex world.

II. METHOD

The research method used was qualitative research using secondary data using a systematic literature review method, where research data was obtained through the results of investigations into existing scientific articles related to mathematical literacy skills. This method was chosen because systematic literature reviews have the advantage of providing transparent and explicit data for use by researchers in searching for and assessing relevant research areas on certain specific topics (Tian et al., 2018; Yunita et al., 2018; Rizki & Priatna, 2019).

The data collection technique was carried out using the publish or perish application by setting several criteria, namely inclusion criteria and exclusion criteria. Researchers limited the search to the latest articles in the last 5 years from the SCOPUS database published between 2018 and 2023. This time frame was chosen to ensure that the articles remained relevant to current conditions. Apart from that, the researcher set criteria by writing the keywords "Mathematical Literacy; Mathematical Realistic Education"

in the publish or publish application to further specialize the filtered data.

Data analysis techniques and drawing conclusions are carried out using the PIECES framework, the steps include the Planning, Identifying, Evaluating, Collecting/ elaborating, Explaining and Summarizing stages (Foster, 2024). For more details, see Figure 1.

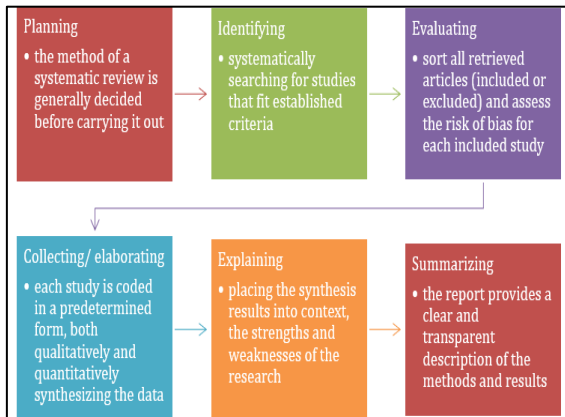


Figure 1. PIECES Framework.

The author collected 200 pieces of literature from the Scopus database with the keywords mathematical literacy using the Publish or Perish application. The literature collected is limited by publication year from 2018 to 2023 with the aim of obtaining new library data. After that, the author carried out a selection of the literature by eliminating articles that were not educational in mathematics and could not be accessed. until there are 18 articles left that can be discussed.

III. RESULT AND DISCUSSION

A. Planning

At this stage the researcher plans regarding what topics will be explored in more depth through a systematic literature review before starting to search for articles. For this reason, researchers set

selection criteria. Selection criteria are a collection of two criteria, namely inclusion and exclusion criteria, which are applied during the article search to ensure that the selected articles are appropriate to the research questions. These criteria can be seen in Table 1.

Table 1.
Inclusion and Exclusion Selection Criteria

Criteria	Indicator
Inclusion	<ol style="list-style-type: none"> Articles are the results of primary research journals or proceedings. Articles published from 2018 to 2023. Articles are written in English. Open Access.
Exclusion	<ol style="list-style-type: none"> Book chapters, theses, short reports, and types of non-empirical studies Articles published not in 2018 – 2023. Articles are written in Indonesian. Close Access

B. Identifying

The next step at the identification stage is to create a search strategy. This research search strategy uses databases that can be accessed via Science Direct, Springer, Taylor & Francis, ERIC, Google Scholar, specifically those indexed by Scopus using the Publish or Perish application to produce articles that can be studied based on keywords that have been adjusted to the researcher's needs. The search string used to generate articles from the database for this study was as follows.

1. Mathematical literacy
2. RME, PMRI, or learning approaches using real life contexts.

This stage is in the form of identifying articles obtained after carrying out the planning stage. To make it easier to obtain

data, researchers used the Publish or Perish application to collect data according to the keywords that had been planned in the planning stage. There were 200 articles detected at the first identification stage, with the keyword "mathematical literacy": "RME", range 2018-2023 with data source from Scopus.

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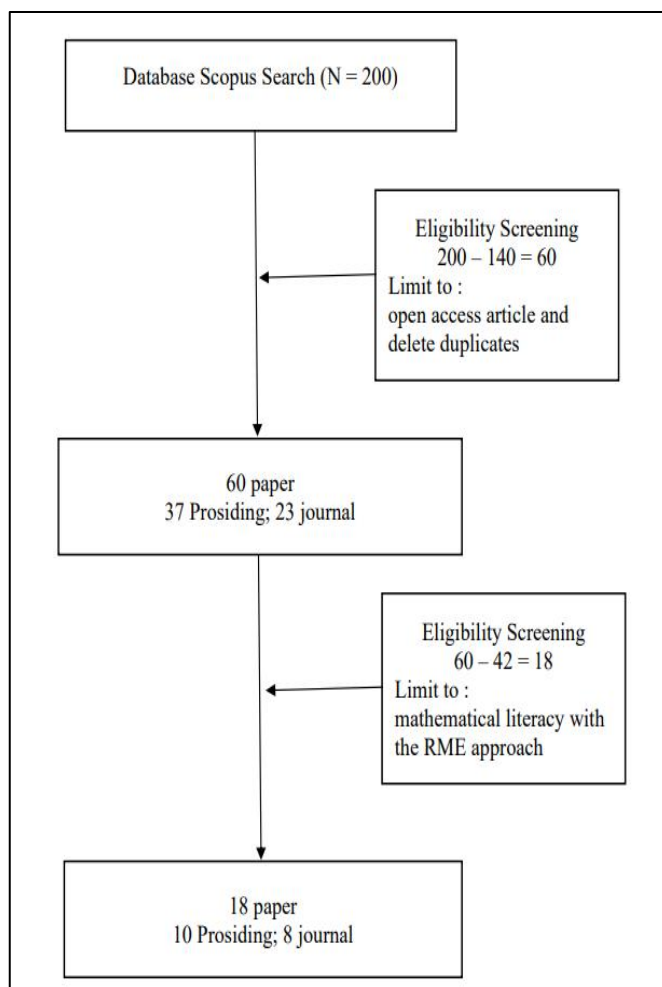


Figure 2. Sample Selection Process.

C. Collecting/combining

Based on the selection process at the evaluation stage, there were 18 articles that met the criteria. Of the 18 articles, 10 articles were obtained from proceedings and 8 articles from journals. Based on the

18 articles obtained, there were 2 articles written by foreign authors, and 16 other articles by Indonesian authors but have been included in the Scopus journal. Based on this, research on RME on mathematical literacy skills has not been widely studied

abroad but is of interest to international journals so that research that raises the theme of RME on mathematical literacy skills is widely published in Scopus indexed journals. The following are details of the grouping of selection results in Table 2.

Table 2.
Article Data Included in The Review

AUTHOR	CONTENT	CONTEXT	RESULTS
Bolstad, 2023 (A)	The content in this article is not displayed clearly. But highlighting more than one piece of content	Problem-solving in real life context	This article produces an analysis of students when confronted with mathematical literacy in certain mathematical content in the context of life and work
Nizar, et al., 2018 (B)	Uncertainty	Football and table tennis at the 2018 Asian Games	The article produces 2 PISA-like questions with sharp content. 1 question using a football context for levels 1 and 4, 1 table tennis context for levels 2 and 3
Jannah, et al., 2019 (C)	Uncertainty and data	soft tennis and volleyball contexts in Asian Games	This research produced 14 PISA-like mathematical questions on uncertainty and data material that focused on the context of soft tennis and volleyball sports games.
Pratiwi, et al., 2019 (D)		long jump context in Asian Games	there were five units consisting of ten items of PISA-like mathematics problems on uncertainty and data using games and athletics in Asian Games contexts. However, only one unit, using long jump in athletics context with 2 questions
Permatasari, et al., 2018 (E)		Football context in Asian games	Produced 9 PISA-like mathematics question items with the Asian game's sports game context, in the form of football unit (3 items), basketball unit (1 item), golf unit (1 item), volleyball unit (1 item), cricket unit (1 item), and bowling unit (2 items).
Dasaprawira, et al., 2019 (F)	Basic Math Skills (BMS)	Tanjung Kalian Mercusuar, Bangka context	This research produced 11 PISA type mathematics questions using the Bangka context valid and practical and has potential effects.
Maryani & Widjajanti, 2020 (G)	Teacher literacy	Teachers' mathematical literacy in real-world contexts	Investigation of mathematics teaching is seen from the way teachers deliver mathematics learning
Siswono, et al., 2018 (H)	mathematical content	Variety of local wisdom in Indonesia	This research produces an analysis of the difficulties faced by designers of PISA questions regarding the authenticity of the context and use of language
Zulkardi & Kohar, 2018 (I)	No Specific Content	Variety of context consisting of personal, occupational, societal, and scientific contexts	produced a description of secondary school mathematics teachers' experiences in designing PISA-like questions
Rifandi, et al., 2019 (J)	numbers, algebra, geometry, and data analysis	real life context	produce mathematical literacy teaching materials with theme-based problem solving abilities in integrated learning for sixth grade elementary school students.

AUTHOR	CONTENT	CONTEXT	RESULTS
Rohman, et al., 2019 (K)	Social arithmetic	Interpreting mathematics in some various contexts and solving the problem in real life	exploring students' literacy skills descriptively and teacher responses in lesson study mathematics learning using the RME approach
Wardono & Mariani, 2020 (L)	Higher Order Thinking Skills (HOTS) mathematics content	Problems in everyday life using e-school	Knowing the development of realistic learning tools (RME) assisted by e-school in improve mathematical literacy and improve higher order thinking abilities (HOTS).
Rusdi, et al, 2020(M)	Numbers, Algebra, Geometry and Measurement	contextual learning	Produce a Plomp learning model on mathematics material using the RME approach to increase students' mathematical literacy.
Nusantara, et al., 2020 (N)	Uncertainty and data	PISAComat	produced PISAComat on the mathematical literacy abilities of middle school students with numeracy content in the context of Covid-19
Maryani & Widjajanti, 2020 (O)	Mathematics content	Contextual teaching and learning	It was found that literacy skills support the relationship between contextual learning and teaching components with several indicators of mathematical literacy
Fauzana, et al., 2020 (P)	Multiplying	Contextual problems that students can imagine	There is a difference in increasing mathematical literacy skills between students who learn using the RME approach and students who learn using conventional learning.
Maslihah, et al., 2021 (Q)	Numerical, geometric and graphical situations	Problem-based learning (PBL) in RME	There is an influence of the Problem Based Learning model with the RME approach on students' mathematical literacy abilities and learning independence
Umbara & Nur'aeni, 2019 (R)	The author focuses on cases of mathematical literacy and does not focus on one content	Learning with RME based on Adobe Flash Professional CS6	Mathematical literacy with RME based on Adobe Flash Professional CS6 is better than students who use conventional learning.

D. Explaining

At this stage, the strengths and weaknesses of the article being studied will

be explained. Explanations will be made based on groupings to answer research questions in Table 3.

Table 3.
Strengths and Weaknesses.

AUTHOR	STRENGTHS	WEAKNESSES
A	The results of the teacher's analysis in teaching mathematical literacy skills have resulted in many suggestions for teacher learning in the future	The research results displayed do not contain any documentation of students doing the work. No documentation is shown in the article, Even though the existence of student documentation while working will be strong evidence that the correct answer being analyzed is the result of the student's work.
B, C, D, E, F	The PISA questions created are able to help students understand mathematical literacy problems well Research on creating PISA-like questions has	

AUTHOR	STRENGTHS	WEAKNESSES
	<p>had a positive impact on students' mathematics learning using the Asian games context</p> <p>The use of PISA-like mathematics questions with long jump in the context of the Asian Games makes students more interested and active when discussing the learning process.</p> <p>Generating student interview data about question types using context can help develop mathematical literacy abilities</p>	
	<p>Produce PISA in the context of Bangka (Tanjung Kalian Lighthouse) that is valid, practical, and has Basic Math Skills (BMS)</p>	<p>Apart from there being no documentation, the results of expert revisions at the question validation stage are also not displayed</p>
<p>G, H, I, J, K, L, M, N, O, P, Q</p>	<p>The explanation is delivered coherently and completely. This research also defines mathematical literacy as a competency needed to meet the demands of life in modern society.</p> <p>The writing in this article discusses future studies regarding problems in presenting PISA assignments in classroom learning practice</p> <p>Raising learning inside and outside the field regarding the application of content to PISA problems</p> <p>Raises the concept of valid teaching material design research using the McKenney and Reeves development model. This model is quite unique for the application of RME to mathematical literacy abilities</p> <p>Using lesson study for RME learning for junior high school students</p> <p>The research theme on e-school is quite unique in the application of RME learning for post-covid times where learning is starting to shift to using technology</p> <p>In the abstract the points of the research to be carried out are clearly stated. The mathematical content that will be delivered is also displayed.</p> <p>Research that raises the issue of Pisa using the context of Covid-19, which was currently hot at the time, is a very interesting topic</p> <p>Explain the importance of learning using context in terms of literature review</p> <p>Experimental research on RME learning and learning with non-RME approaches. This research describes the results of field tests directly related to RME learning in the classroom</p> <p>Combination research on the effect of</p>	<p>There is no use of tables to simplify explanations</p> <p>There are no significant weaknesses in the article. each part is discussed well</p> <p>Unfortunately in this study, the media created was not displayed. The material content made in teaching materials has also not been explained well</p> <p>The research method is not explained in detail</p> <p>Unfortunately e-school media is not displayed, and what material is applied in e-school is also not presented in detail</p> <p>Examples of context-based questions are not yet clearly visible in the research conducted</p> <p>Attached student answers are not accompanied by photos of students working on them.</p> <p>In this research, the literature review did not explain the methods used and how to collect the data</p> <p>The discussion is still too brief and there is no documentation of activities to complete the quantitative calculation data</p> <p>The research subjects are not displayed</p>

AUTHOR	STRENGTHS	WEAKNESSES
	implementing PBL with the RME approach using a sequential explanation design on mathematical literacy abilities and learning independence	clearly, there is no further discussion of the research results displayed
R	students' mathematical literacy with RME based on Adobe Flash Professional CS is better than with conventional learning	A picture of the product is not displayed

Most of the research results found explain positive support for the RME, PMRI, or context approaches to mathematical literacy skills and abilities. Fauzana et al (2020). explained that students' mathematical literacy skills increased after learning using the RME approach. Students' mathematical literacy increased after implementing the Plomp learning model with the RME approach (Rusdi et al., 2020). Apart from that, students' metaphysical literacy is also able to help students solve other mathematical problems based on their relationship to certain mathematical contexts in their personal and work lives (Bolstad, 2023).

Mathematical literacy skills using the RME, PMRI, or context learning approaches are also widely used in preparing PISA assignments. such as, PISA questions regarding uncertainty in the context of football and table tennis (Nizar et al., 2018), content and uncertainty data using the ASIAN Games context in sports games (Permatasari et al., 2018) data and uncertainty using the context of soft tennis and volleyball at the Asian Games (Jannah et al., 2019), using PISA standard questions in the Bangka context (Dasaprawira et al., 2019), and PISA with numeracy content in the Covid-19 context (Nusantara et al., 2020), where PISA questions are able to

support students' mathematical literacy skills with a context-based approach.

Umbara and Nuraeni (2019), explained that one of the characteristics of mathematical literacy is skills that can help students realize that mathematics plays a role in every aspect of life. Mathematical literacy is also an individual's ability to formulate, use and interpret mathematics in various contexts. Therefore, literacy and a realistic mathematical approach are closely related to each other. Other characteristics are explained in the research of Fauzana et al (2020) that the curriculum currently being implemented in Indonesia aims to create a mathematics learning process that can explore students' problem solving, reasoning, communication, connection and representation abilities.

Mathematical literacy is not just the ability to read and write. Rohman et al (2019) explained that mathematical literacy can make someone can think critically, be able to solve problems, communicate effectively and develop potential and participate actively in social life through various contexts. The characteristics of mathematical literacy include having the same characteristics as a realistic mathematical approach, namely emphasizing awareness of the usefulness and ability to use mathematics in a variety

of different contexts to prepare students to solve problems in future life (Bolstad, 2020).

E. Summarizing

Based on the PIECES framework research stages previously explained. Mathematical literacy skills using the PMRI and RME approaches have been widely studied. These include the ASIAN games context (Jannah et al., 2019) using the Bangka context (Dasaprawira et al., 2019) the Covid-19 context (Nusantara et al., 2020) using the Plomp model (Rusdi et al., 2020), assisted by Adobe Flash IT professionals (Umbara & Nuraeni, 2019), application of hot questions (Wardono & Mariani, 2020), analyzing difficulties and errors in making PISA tasks (Zulkardi & Kohar, 2018), to in-depth analysis through student interviews (Bolstad, 2020) and teachers in learning mathematical literacy (Bolstad, 2023).

Zulkardi and Kohar (2018) explained in their findings, based on many studies on the PISA framework found, it was found that mathematical literacy was strongly influenced by the realistic mathematics education (RME) approach where learning emphasized the importance of solving mathematical problems in real world contexts. This can be a promising basic theory for developing mathematical literacy-based teaching programs using the RME approach. It is also important to emphasize that teachers have an important role in achieving mathematical literacy skills in the application of learning. (Bolstad, 2023) explains that further research is currently needed on how to

help teachers implement mathematical literacy teaching in the classroom.

In his other research, Bolstad (2020) stated that the interpretation of mathematical literacy in objectification theory can provide a new perspective regarding how mathematical literacy can be understood and developed and needs to be studied further. Objectification theory focuses on how students and teachers produce knowledge with historical and cultural backgrounds, as well as how they position themselves as subjects in society and school (Bolstad, 2020).

In line with that, Siswono et al (2018) suggest the same thing, namely the study of professional developers to design a series of explicit learning activities that support teacher development in understanding authentic contexts and life problem profiles using the PISA mathematical framework needs to be studied further. This is because there are still many teachers who experience difficulties in compiling test items using PISA characteristics. Apart from that, development also needs to be carried out for various other contexts that have not been discussed in previous research.

Some future research opportunities regarding RME in mathematical literacy that have clearly not been widely researched at this time are articles that address the context of religious tourism. Religious tourism is a form that is motivated exclusively for religious reasons and is one of the oldest types of tourism which is a worldwide religious historical phenomenon (Rinschede, 1992). Especially Cirebon religious tourism. In fact, learning

in the context of religious tourism has an indirect influence on learning motivation, environmental motivation, religious motivation and cultural motivation (Ramírez & Portillo, 2020). In Cirebon, there are many religious tourist attractions such as Sunyaragi Cave (Suwandi et al., 2021) Cirebon Ancient Mosque (Badar, 2021), Sunan Gunung Jati Tomb (Hamzah, 2022), Kasepuhan Palace (Syafroni, 2023), and many more. there are many more that have not been explored optimally in mathematics learning.

Apart from the context of religious tourism, there are many other contexts that could provide opportunities for further research related to mathematical literacy learning using the RME approach. Apart from that, there are also many applications of other content that have not been researched and are opportunities for further study. Moreover, by combining content, context, competence and technology that is currently popular. This will be very interesting to discuss in future research.

However, this article also has weaknesses. Apart from the findings articles that have been presented and analyzed previously, it turns out that several other articles were found related to mathematical literacy using a context-based approach. Kolar and Hodnik (2021) apply non-contextual and contextual problem solving involving mathematical content. Jailani et al (2020) examined three aspects of mathematical literacy skills examined in the research, namely content, process, and context. Development of local context-based mathematics literacy

modules (Susanta et al., 2022) Context-based mathematical literacy research has also been widely applied to other content such as mathematical economics (Ozkale & Erdogan, 2022), language, symbols, and mathematical models (Vivi et al., 2023) and Algebra (Awiria & Dariyanto, 2022). This shows that retrieving articles with the keyword "mathematical literacy" using the publish or perish application has weaknesses. Even so, the existing weaknesses certainly do not reduce the positive benefits obtained in the research that has been carried out. In the future, similar research can be carried out with much more detailed and in-depth studies.

IV. CONCLUSION

Based on the results and discussion, it was found that several applications of the RME learning approach to mathematical literacy skills that have been researched include creating PISA questions, HOTS questions, using various contexts that are close to students' daily lives, as well as teacher and student analysis in literacy learning at school.

The characteristics of learning with the RME approach to mathematical literacy skills can also be identified, including skills that can help students realize that mathematics plays a role in every aspect of life, create a mathematics learning process that can explore problem solving, reasoning, student communication, and make someone have the ability to think critically, be able to solve problems, communicate effectively and develop potential as well as actively participate in social life through various contexts.

Apart from that, this research provides suggestions for research opportunities that can be carried out, one of which is by using contexts that are rarely researched, such as the context of tourism or religious tourism in a particular area. The application of RME and mathematical literacy through digital media can also be an opportunity and is still not widely researched. Even so, this research certainly still has a few weaknesses. Furthermore, a similar study can be made with a more detailed and in-depth discussion, and from more diverse sources, not just Scopus.

ACKNOWLEDGEMENT

The authors would like to extend their sincere gratitude to the Minister of Education, Culture, Research, and Technology of the Republic of Indonesia for the financial support provided through the 'Penelitian Disertasi Doktor' (PDD) program, under contract number 090/E5/PG.02.00.PL/2024.

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