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Unlocking the secrets of students' mathematical literacy to solve mathematical problems: A systematic literature review

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Abstract
Mathematical literacy is the ability to use mathematical knowledge in real-life situations, making it an essential component of education because of its importance in solving everyday problems. Mathematical literacy is also part of the Program for International Student Assessment (PISA) global assessment. Because of the importance of the subject, this Systematic Literature Review (SLR) investigated the relationship between students' mathematical literacy and their ability to solve mathematical problems. This SLR uses the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) approach was used, and articles published from January 2013 to August 2023 were obtained from databases including ERIC (342), ProQuest (1,329), and Scopus (27). Following PRISMA, a total of 20 articles were included in the review. Of the 20 articles, most were conducted on junior high school students in Turkey. The majority of reviewed studies found students to have a low level of mathematical literacy, which caused difficulties in formulating problems. The examined studies also revealed several internal and external factors affecting mathematical literacy. Problems used by PISA were the most frequently employed to measure students' mathematical literacy in the reviewed studies.

Keywords: mathematical literacy, mathematical problems, mathematics education, systematic literature

INTRODUCTION

Background

The modern era sees mathematical literacy as an essential component of a successful life (Stacey & Turner, 2015a) because it is necessary for solving everyday problems (Genc & Erbas, 2019). The abilities that comprise mathematical literacy are relevant both inside and outside the classroom (Rosa & Orey, 2015). The importance of mathematical literacy makes it a vital part of the competencies that students must master at each level of education. World Economic Forum (WEF, 2015) divides basic literacy into six categories: reading, mathematical, science, financial, digital, and cultural and citizenship literacy (Shara et al., 2020). Mathematical literacy is a domain considered by the program for international student assessment (PISA) run by the Organization of Economic Co-operation and Development (OECD) (Stacey, 2011). This condition makes mathematical literacy a crucial variable in the development of mathematics education in the world and a trending research topic.

Despite the recent increase in research on mathematical literacy (Kurniawati & Mahmudi, 2019; Muhaimin & Kholid, 2023; Ozkale & Ozdemir Erdogan,

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Contribution to the literature

- Gaps in Literacy: Despite numerous individual studies on mathematical literacy, there remains a significant void in comprehensive reviews that synthesize the findings. This article fills this gap by combining various research findings into a coherent narrative.
- Global Relevance: Given that PISA (Programme for International Student Assessment) is a global benchmark, the insights gained from this review are highly relevant for educators, policymakers, and stakeholders in various countries and education systems.
- Pedagogical Implications: By delving deeper into mathematical problem-solving skills, this review offers valuable insights for curriculum designers, educators, and teacher training programs. It guides for improving teaching methodology to strengthen students' mathematical competence.

2022; Wijaya, 2016), students worldwide, including in developed countries, continue to need help to achieve adequate mathematical literacy. Many students find it difficult to understand mathematical concepts (Wijaya et al., 2014), relate them to real-world situations (Muhaimin & Kholid, 2023), and apply them to solve problems (Tanujaya et al., 2017), reflecting a gap between what is taught in school and the skills needed for real life. Although various approaches and methods of teaching mathematics have been applied, increasing students' mathematical literacy remains a challenge.

Mathematical literacy is more about using one's mathematical knowledge to make decisions based on the available information than about memorizing mathematical formulas or techniques (Chiwetalu & Ratner, 2019). Thus, mathematical literacy involves understanding basic mathematical concepts and being able to apply them in real-life situations. When students are given mathematical problems related to real situations, they are compelled to use their mathematical knowledge and critical thinking, reasoning, and analytical skills (Maryani & Widjajanti, 2020; OECD, 2019). This is because mathematical problems are problems related to real situations or conditions that require understanding mathematical concepts, principles, or techniques to find solutions (Hilbert, 1984). Afni and Hartono (2020) concluded that having students solve mathematical problems related to real-world situations gives them the opportunity to apply their knowledge in relevant contexts. Therefore, mathematical problems are often utilized as a tool to assess students' mathematical literacy and to enhance their mathematical abilities (Muhaimin & Kholid, 2023; Saputri et al., 2018).

To provide a more comprehensive evaluation of students' mathematical literacy in solving mathematical problems, conducting a systematic literature review (SLR) study to investigate various studies is necessary. It was expected to provide in-depth insight into the latest trends, findings, and recommendations from research around the world to serve as a basis for developing effective approaches and strategies to improve students' mathematical literacy. Thus, this study aimed to investigate students' mathematical literacy abilities as they relate to solving mathematical problems based on the results of research conducted in the last decade. Through this research, it is hoped that it can help education stakeholders (such as teachers, policymakers, and researchers) to understand the pros and cons of students' mathematical literacy so that they can make a real contribution in efforts to improve the quality of mathematical literacy in the future.

Previous SLRs on mathematical literacy have been limited to studies discussing the characteristics of students' mathematical literacy (Aisyah & Juandi, 2022; Rum & Juandi, 2022), while others considered the characteristics of elementary school students' mathematical literacy (Nurmasari et al., 2023), and the impact of using ICT on mathematical literacy (Juandi et al., 2022). However, no prior SLRs have examined studies on the relationship between students' mathematical literacy skills and their ability to solve mathematical problems. This focus encompasses the challenges students face while tackling mathematical problems and the factors influencing the quality of their mathematical literacy. Understanding the prior research on the subject from this perspective is expected to help teachers identify potential difficulties faced by students solving mathematical problems and determine the factors that influence students' mathematical literacy. It is also expected to aid in the creation of learning activities designed to improve students' mathematical literacy. Additionally, this review highlights the current trends in mathematical literacy research and explores the underlying reasons, making it more intriguing to delve into until completion.

Thus, this study aimed to collect, assess, and synthesize data on students' mathematical literacy as it relates to the solving of mathematical problems. The objectives included revealing the trends in mathematical literacy research, exploring the quality of mathematical literacy, examining the factors influencing mathematical literacy, and identifying the mathematical problems commonly used to assess students' mathematical literacy. This comprehensive scientific review provides clear answers to the following predetermined research questions (RQ):

1. How is the geographical distribution of the research sites?
2. How is students' mathematical literacy in solving mathematical problems based on the distribution of the research sites?
3. What are the factors affecting mathematical literacy?
4. What are the mathematical problems used to measure mathematical literacy?

Theoretical Framework

Mathematical literacy

Literacy skills are fundamental abilities that students must master in school to solve their everyday problems (Jablonka, 2003; Yuliati, 2017). This is supported by Astuti (2018) statement that literacy skills should be a learner's mastery for daily life fulfillment in this century. Thus, literacy skills are essential for individuals to solve problems related to their daily lives. In mathematics, the term mathematical literacy was first discussed in NCTM (1989), referring to the ability to speculate, explore, reason, and logically solve problems effectively. Today, the term mathematical literacy is synonymous with the existence of PISA, where OECD defines mathematical literacy as the ability to formulate, apply, and interpret mathematical problems (OECD, 2021). The ability to formulate refers to the attempt to identify mathematical problems, the ability to apply refers to the ability to apply various formulas to solve problems, and the ability to interpret refers to the ability to provide an evaluation involving the context of the problem (OECD, 2015, 2019, 2021). These abilities alone are insufficient to underpin mathematical literacy; according to OECD (2021), reasoning abilities are also required in this scope when using mathematical concepts (formulas, algorithms, and procedures), indicating a need for sound mathematical reasoning. The relationship between mathematical literacy and reasoning is explicitly shown in **Figure 1**.

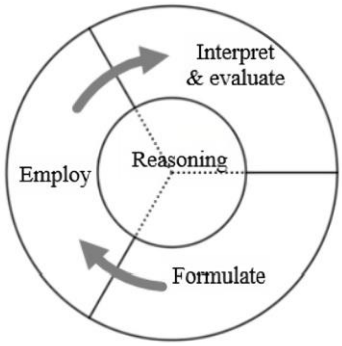

Figure 1. Fundamental skills that encompass mathematical literacy (OECD, 2021, reprinted with permission)

Other fundamental skills in mathematics are also discussed by OECD, including communication, mathematization, representations, reasoning and opinions, ability to choose strategies to solve problems, ability to use symbolic, formal, and technical languages and operations, and ability to use mathematical tools. These seven basic mathematical skills fill each component of mathematical literacy process skills, forming relationships between the skills used in the composition of PISA mathematics problems (Stacey & Turner, 2015). Similar to general problems, PISA is used to measure participants' abilities. Referring to the completed PISA results, OECD (2019) categorizes six levels of mathematical literacy hierarchically. At level 1, students can recognize the context of the problem and solve it with routine procedures; at level 2, students begin to interpret the problem's context and apply it to a formula and procedure; at level 3, students can interpret the problem and apply representations of various information differences; at level 4, students can solve real-world problems accurately and effectively using clear steps; at level 5, students can identify information and make hypotheses and problem-solving strategies; at level 6, students can reason to determine the concept of complex information.

Mathematical literacy assists students in applying mathematical concepts to problems in their daily lives (Christiansen, 2007; Sumirattana et al., 2017; Umbara & Suryadi, 2019). Recognizing the importance of mathematical literacy, this skill is now applied in schools as a fundamental skill that must be mastered since the introduction of AKM (minimum competency assessment). However, in reality, many students still need help to apply mathematical concepts in contextual problems. This is due to several factors, including:

(1) low mathematical literacy due to inadequate educational locations and facilities (Porras et al., 2019) and

(2) factors influencing mathematical literacy include personal factors, instructional factors, and environmental factors (Rahayu et al., 2021), with personal factors relating to a student's abilities and qualities, instructional factors involving the quality of the learning process, and environmental factors originating from various components supporting the learning process (Pratama, 2020).

Mathematical problems

Problems involving the application of mathematical content to everyday life are mathematical problems (Silver, 1985), and in schools, these are considered non-routine mathematical problems that involve everyday problems. This is because mathematical problems involve different thinking, requiring various mathematical procedures and formulas to solve problems, similar to non-routine problems (English, 1996; Hwang et al., 2007; Pantziara et al., 2009). From various opinions above, it can be concluded that a mathematical problems is a non-routine problem

Table 1. Criteria of inclusion & exclusion in screening stage

Criteria	Inclusion	Exclusion
Type of publication	Solely journal articles	Non-empirical studies & proceeding articles
Language	English	Other
Year of publication	Publications from 2013 to 2023	Research outside year range of inclusion requirements

involving the application of mathematical concepts in everyday life, requiring diverse thinking, and the use of various procedures and mathematical formulas to achieve a solution. Mathematical problems are commonly found in specific tests such as PISA and TIMSS (Martin & Mullis, 2019; OECD, 2015, 2019, 2021). These two tests play a role in testing and evaluating students' literacy abilities globally, and the problems tested go beyond the typical mathematics problems found in schools (Fenanlampir et al., 2019). Mathematical problems have characteristics or components, enabling them to be included in literacy tests.

Context, content, and process are components that must be present in each PISA and TIMSS problem (Hutchison & Schagen, 2007). Content represents the material or subject learned in the classroom during learning (change and relationships, space and shape, quantity, and uncertainty and data). PISA's context represents something indicating areas of life requiring literacy skills for various everyday problems (personal, occupational, societal, and scientific), and PISA process consists of formulating mathematical problems and applying concepts, facts, procedures, and mathematical tools, as well as interpreting, using, and evaluating the obtained results (Martin & Mullis, 2019; OECD, 2015; She et al., 2018; Stacey, 2015). These three components are interrelated and form the basis for each PISA problem item's composition.

Considering the challenges in the Indonesian education system, which consistently ranks low in global scale tests such as PISA and TIMSS, the Indonesian government and the Ministry of Education introduced AKM in 2020 to enhance students' literacy and numeracy skills (Handayani et al., 2021; Herman et al., 2022; Ministry of Education, 2020). The implementation of AKM aims to improve students' literacy skills, including both numeracy and reading literacy, reinforcing students' character in Indonesia (Herman et al., 2022). In terms of AKM problems, there are similarities with PISA or TIMSS problems, containing content (numbers, measurement and geometry, data and uncertainty, and algebra), context (personal, sociocultural, and scientific), and cognitive processes in each problem consisting of understanding, application, and reasoning (Ministry of Education, 2020). AKM framework encompasses content, context, and processes within its domain. Therefore, besides measuring students' mathematical literacy, AKM provides evaluation, and through drill exercises with AKM problems, it can enhance mathematical literacy (Herman et al., 2022).

METHODS

We conducted a systematic review to comprehensively understand the literature on students' mathematical literacy in solving mathematical problems. According to Moher et al. (2009), a systematic review is a literature review that addresses clearly formulated questions to gather and analyze studies or data using a systematic method that involves identifying, selecting, and assessing relevant research. The preferred reporting items for systematic reviews and meta-analysis (PRISMA) were applied as the approach in this review process. PRISMA was chosen for its systematic stages in the review process. According to Moher et al. (2009), this systematic review involved four stages: identification, screening, eligibility, and inclusion. The systematic review process with PRISMA in this study is visualized in **Figure 2**.

Identification

In this stage, the exploration of articles focused on the ERIC, ProQuest, and Scopus databases. These databases were selected due to their relevance to the researcher's field of study in education, and the journals within these databases are reputable, ensuring the retrieval of quality articles. The search process was conducted in February 2023 using keywords ((“mathematical literacy”) AND (“mathematical problems”) AND (“mathematics education” OR “mathematics”)) to facilitate the researcher in finding relevant articles in each database. A total of 1,698 articles were obtained, with 342 records in ERIC database, 1,329 in ProQuest, and 27 in Scopus.

Screening

Articles obtained at the identification stage are then collected in **Table 1** based on the original database for the screening process. This screening stage is carried out by reviewing and selecting articles based on the following criteria:

(1) published in scientific journals with peer review to ensure that the selected articles go through high-quality reviews,

(2) written in English, and

(3) released in the last decade, from January 2013 to August 2023, to study publication trends.

Retrieval of articles in the last decade is based on the global trend of PISA assessments and other international assessments that focus on students' mathematical literacy that have provided data at specific intervals, and this condition has an impact on the number of studies in this period. Then, the researcher identified gaps in

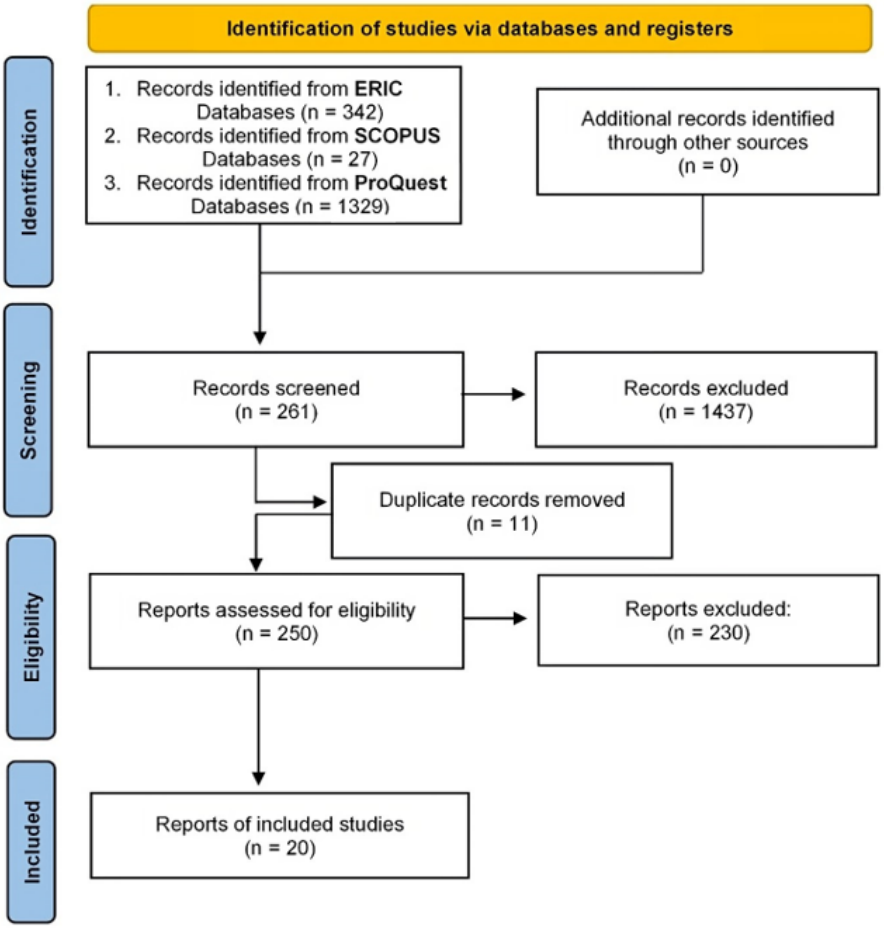

Figure 2. PRISMA flowchart (Source: Authors' own elaboration)

Table 2. Criteria of inclusion & exclusion in eligibility stage

Criteria	Inclusion	Exclusion
Article title & keyword	An appropriate title & keyword that complied with study's requirements	Did not match requirements of study & had an irrelevant title & keyword
Content	A relevant to research question	An irrelevant to research question
Field of article study	Mathematics education	Other
Accessibility	Full-text articles or open access	Preview articles or articles requiring a payment

previous research that found gaps or deficiencies in previous research conducted and indicated the need for further research so that the research range in the last decade (January 2013 to August 2023) was determined.

Based on the inclusion criteria, out of 1,698 articles obtained at the identification stage, researchers only took 261 articles at the screening stage. and eliminated 1,437 articles that did not meet the inclusion criteria at the screening stage. The inclusion and exclusion criteria for articles in the screening stage are displayed in **Table 1**.

Eligibility

Before starting this stage, researchers search for duplicate articles. 11 articles are duplicates and must be removed leaving 250 articles. In the Eligibility stage, the remaining articles were then reviewed based on their eligibility. The researcher reviewed the remaining articles after the exclusion of duplicate articles with the following criteria:

(1) relevance to title and keywords,

(2) relevance to the research question,

(3) relevance to the researcher's field of study, and

(4) accessibility of articles.

At this stage, a total of 230 articles that did not meet the criteria were excluded. Besides, 211 articles were irrelevant to variables and keywords, while six articles were not relevant to the type of research or method. Besides, 13 articles were not relevant to the research question. Finally, the researcher obtained 20 articles to be analyzed in order to answer research questions. The inclusion and exclusion criteria for articles in the eligibility stage are presented in **Table 2**.

Included

The researcher obtained 20 articles have been obtained through PRISMA process. Before discussing each article according to the research questions, we

Table 3. Analysis of reviewed articles

No	Author	Country	EL	Quality	Factors	MP
1	Altun (2017)	Turkey	Junior high school	Low	Internal	PISA
2	Canbazoglu and Tarim (2020)	Turkey	Prospective teachers	Low	External	HOTS
3	Aksu et al. (2017)	Turkey	Junior high school	Low	External	PISA
4	Kozakli Ulger et al. (2022)	Turkey	Teachers	Low	External	Open ended
5	Dewantara et al. (2015)	Indonesia	Junior high school	Low	Internal	PISA
6	Almarashdi and Jarrah (2023)	Saudi Arabia	Senior high school	Low	Internal	PISA
7	Aksu and Guzeller (2016)	Turkey	Junior high school	Low	Internal	PISA
8	Zainiyah and Marsigit (2019)	Indonesia	Elementary school	High	Internal	PISA
9	Firdaus and Herman (2017)	Indonesia	Elementary school	Low	External	Contextual
10	Yenmez and Gokce (2023)	Turkey	Prospective teachers	Low	Internal	PISA
11	Tapan et al. (2021)	Turkey	Junior high school	Low	External	PISA
12	Kolar and Hodnik (2021)	Slovenia	Elementary school	Low	External	Contextual
13	Jailani et al. (2020)	Indonesia	Junior high school	Low	External	PISA
14	Fauzi and Chano (2022)	Indonesia	Elementary school	Low	External	Contextual
15	Haara et al. (2021)	Norway	Junior high school	Low	External	Contextual
16	Ozgen (2019)	Turkey	Prospective teachers	Low	Internal	Open ended
17	Hwang and Ham (2021)	Korea	Junior high school	Low	External	PISA
18	Kusuma et al. (2022)	Indonesia	Junior high school	Low	Internal	PISA
19	Kholid et al. (2022)	Indonesia	Junior high school	Low	External	PISA
20	Botha et al. (2013)	South Africa	Junior high school	Low	External	PISA

Note. EL: Education levels & MP: Mathematical problems

summarized and presented the articles in **Table 3** based on the topics or research questions posed.

RESULTS & DISCUSSION

The findings of 20 filtered articles will be explicitly presented below based on the topics derived from the research questions. These include the distribution of research locations, the education level of the subjects, the quality of mathematical literacy based on the distribution of countries, where the research was conducted and the education level of the research subjects, the mathematical literacy theories used, mathematical literacy indicators, factors influencing mathematical literacy when solving mathematical problems, and the types of mathematical problems researchers used to measure mathematical literacy. Tables, diagrams, charts, and various illustrations will also be included to clarify visualizations for readers, and researchers have attempted to categorize each similar research result.

RQ1. Geographical Distribution of Research

Based on the results of a systematic review with PRISMA process, collected 20 review articles from seven countries. Turkey dominates the distribution of research location with a percentage of 40% (Aksu et al., 2017; Aksu & Guzeller, 2016; Altun, 2017; Canbazoglu & Tarim, 2020; Kozakli Ulger et al., 2022; Ozgen, 2019; Tapan Broutin et al., 2021; Yenmez & Gokce, 2023), followed by Indonesia with a percentage of 35% (Dewantara et al., 2015; Fauzi & Chano, 2022; Firdaus & Herman, 2017; Jailani et al., 2020; Kholid et al., 2022; Kusuma et al., 2022; Zainiyah & Marsigit, 2019), and 5% of each in Korea (Hwang & Ham, 2021), South Africa (Botha et al., 2013), Saudi Arabia (Almarashdi & Jarrah, 2023), Norway (Haara, 2018), and Slovenia (Kolar & Hodnik, 2021). The distribution of countries can be seen clearly in **Figure 3**.

Figure 3. Distribution of articles by country of research location (Source: Authors' own elaboration)

Through a review of articles, seven countries that have conducted research on students' mathematical literacy were identified, including Turkey, Indonesia, Saudi Arabia, Slovenia, Korea, South Africa, and Norway. All these countries have an active participant record in PISA program (Schleicher, 2018). Based on the results obtained (**Figure 3**), it is evident that Turkey and Indonesia exhibit the highest majority levels regarding the quantitative distribution of demographic research compared to other countries (see **Figure 3**). Various opinions and theories explain that when a country experiences significant disparities, many aspects contemplate and seek solutions to minimize and address these issues (Suharta & Suarjana, 2018; Zahra et al., 2014). These statements establish a research trend on mathematical literacy in Indonesia and Turkey,

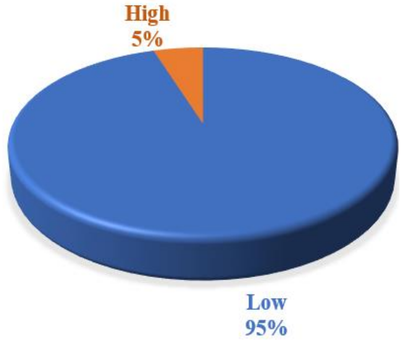

Figure 4. Distribution of quality of mathematical literacy (Source: Authors' own elaboration)

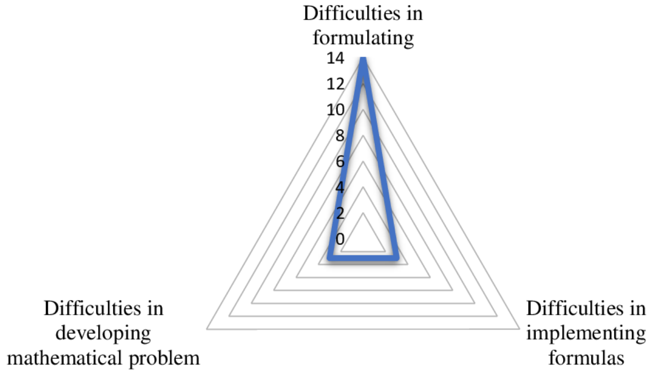

Figure 5. Distribution of mathematical literacy characteristics (Source: Authors' own elaboration)

analyzing and finding solutions to the identified low mathematical literacy (Lailiyah, 2017).

Apart from the efforts of researchers to improve mathematical literacy based on PISA, the quantity of mathematical literacy studies is also influenced by educational sector policies such as the curriculum. Analyzing the geographical data of the research shows that Turkey and Indonesia have the highest quantity of research. This aligns with the educational policies in Turkey, which involve mathematical literacy as a crucial component of its educational curriculum (Milli Eğitim Bakanlığı [Ministry of Education], 2013). Then, in Indonesia, the government began formulating AKM policy in 2020 to evaluate students' mathematical literacy in the country, the results of this evaluation serve as an alternative solution to improve mathematical literacy (Ministry of Education, 2020). Therefore, the various conditions above form the basis that the quantity of this study is influenced by the efforts of the government and researchers to increase mathematical literacy in their countries.

RQ2. Quality of Mathematical Literacy

All articles collected have justified the quality of mathematical literacy possessed by research subjects or samples. We identified two categories: high and low literacy (see **Figure 4**). Based on the 20 articles obtained, the majority of students still need to improve their mathematical literacy, and 19 articles show low-quality mathematical literacy. From some countries (**Figure 3**), Turkey is the dominating country with eight studies (Aksu et al., 2017; Aksu & Guzeller, 2016; Altun, 2017; Canbazoglu & Tarim, 2020; Kozakli Ulger et al., 2022; Ozgen, 2019; Tapan Broutin et al., 2021; Yenmez & Gokce, 2023), followed by Indonesia with six studies (Dewantara et al., 2015; Fauzi & Chano, 2022; Firdaus & Herman, 2017; Jailani et al., 2020; Kholid et al., 2022; Kusuma et al., 2022), and South Korea with one study (Hwang & Ham, 2021), South Africa (Botha et al., 2013), Saudi Arabia (Almarashdi & Jarrah, 2023), Norway (Haara, 2018), and Slovenia (Kolar & Hodnik, 2021). Then, one of the studies located in Indonesia had high mathematical literacy results (Zainiyah & Marsigit, 2019). The distribution of mathematical literacy characteristics can be seen in **Figure 5**.

The profile of mathematical literacy quality obtained shows a dominance of abilities still in the low range, with a 95% percentage from the data of 20 articles (see **Figure 4**). A unique finding is that one article indicates high-quality mathematical literacy. This data outlier comes from a study conducted in Indonesia, contrary to PISA results that show Indonesia itself obtaining low mathematical literacy scores (Schleicher, 2018). After tracing, the research was carried out at Muhammadiyah Condongcatur Elementary School, which, according to data, holds the third position in Sleman Regency, Yogyakarta (Kemendikbud, 2013). Although Indonesia is ranked low in PISA competition, certain regions in Indonesia may have good human resources because PISA participants are randomly selected in each country (OECD, 2023). This confirms the conditions of this unique finding.

We categorized mathematical literacy characteristics into three (see **Figure 5**). From 19 studies, it can be observed that the quality of mathematical literacy is low. 14 studies revealed that students had difficulty formulating mathematical problems (Aksu et al., 2017; Aksu & Guzeller, 2016; Altun, 2017; Botha et al., 2013; Canbazoglu & Tarim, 2020; Fauzi & Chano, 2022; Firdaus & Herman, 2017; Haara, 2018; Hwang & Ham, 2021; Jailani et al., 2020; Kholid et al., 2022; Kolar & Hodnik, 2021; Ozgen, 2019; Tapan Broutin et al., 2021), three studies revealed that students had difficulty implementing formulas (Almarashdi & Jarrah, 2023; Dewantara et al., 2015; Kusuma et al., 2022), and the rest revealed difficulties in developing mathematical problems (Kozakli Ulger et al., 2022; Yenmez & Gokce, 2023; Zainiyah & Marsigit, 2019).

Difficulties in formulating and applying formulas were found by subjects at the school level (elementary to senior high school), and difficulties in developing mathematical problems were experienced by educators (teachers and prospective teachers).

Turkey remains the majority nominee, indicating low results in mathematical literacy problem-solving with eight articles, followed by Indonesia with six articles. This finding aligns with OECD survey results through PISA test, indicating that both countries can only reach level 1 (Indonesia) and level 2 (Turkey) out of the highest six levels. Looking at the country rankings, Turkey is at position 42, and Indonesia is at position 73 out of 79 participating countries in the 2018 PISA (Schleicher, 2018).

From the discussed studies, students face difficulties in understanding and formulating contextual problems, which is a problem that predominantly affects students at the beginning of solving mathematical problems, as shown explicitly in **Figure 5**.

Abdullah et al. (2015) found that it is difficult to identify the initial problem, so the answers obtained will be wrong. The conditions align with mathematics' systematic nature (Widodo et al., 2018). Besides, students had difficulties applying mathematical formulas to solve mathematical problems. Schoenfeld (1988) stated that the ability to memorize a formula is not enough to solve mathematical problems as remembering based on C1 Bloom's theory is the lowest cognitive level (Krathwohl, 2008). Many mathematical formulas must be synthesized and collaborated with other formulas to be able to solve mathematical problems. For example, higher order thinking skill (HOTS) problem has the characteristics of a minimum C4 problem (analysis) (Syafryadin et al., 2021). The difficulty experienced by mathematics teachers and prospective teachers is to create mathematical problems due to a lack of qualifications and experience (Ulger et al., 2022). Besides, teachers are the central controller in the learning process, so they are responsible for the abilities of their students (Puspitarini & Hanif, 2019). The low mathematical literacy of students requires support from various parties. For example, in Indonesia, AKM has been implemented to measure students' reading literacy and mathematical literacy so that teachers can develop learning methods and strategies according to students' competency levels (Ministry of Education, 2020).

Indeed, it is unfair to only look at one side of students' abilities and justify the low ability of these students because of their personalities. Examining different scopes and components, such as teachers, is also necessary. Teacher competence plays a significant influence on the student's abilities, either good or bad (Li et al., 2018; Polk, 2006; Wery & Thomson, 2013) because the knowledge students acquire in the process of transferring knowledge comes from the teacher (Gou et al., 2021). The selection of teachers and prospective teachers as the subjects of the study is not only to find out their abilities in specific mathematical literacy problems but also to find out various types of methods, teaching materials, and learning approaches that are effective in increasing mathematical literacy (Yenmez & Gokce, 2023; Canbazoglu & Tarim, 2020; Ulger et al., 2022; Ozgen, 2019).

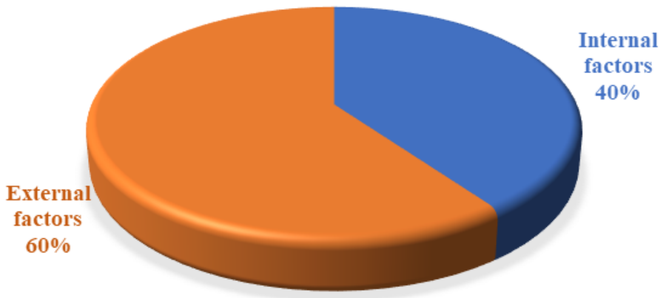

Figure 6. Distribution of mathematical literacy factors (Source: Authors' own elaboration)

RQ3. Mathematical Literacy Factors in Solving Mathematical Problems

The low mathematical literacy of students is caused by many factors. After reviewing 20 articles, some factors affecting mathematical literacy, namely internal factors (n=8) and external factors (n=12). Internal factors are factors that arise from within the individual, while external factors come from outside the individual. Internal factors obtained are beliefs, motivation (Altun, 2017), motivation (Altun, 2017), motivation, the quantity of training (Dewantara et al., 2015; Kozakli Ulger et al., 2022), gender (Almarashdi & Jarrah, 2023), self-efficacy (Aksu & Guzeller, 2016), anxiety (Aksu & Guzeller, 2016), learning discipline (Aksu et al., 2017), reading literacy habit (Zainiyah & Marsigit, 2019), academic value (Yenmez & Gokce, 2023), age (Jailani et al., 2020), and students experience in working on problems (Ozgen, 2019). Then external factors cover the learning process (Botha et al., 2013; Canbazoglu & Tarim, 2020), student and teacher ratios (Aksu et al., 2017), learning models (Firdaus & Herman, 2017), mathematical modeling (Tapan Broutin et al., 2021; Yenmez & Gokce, 2023), learning approaches, teacher support (Kolar & Hodnik, 2021), ICT (Kolar & Hodnik, 2021), textbooks (Kolar & Hodnik, 2021), school level (Jailani et al., 2020), meaningful learning (Fauzi & Chano, 2022), culture (Haara, 2018), local resources (Haara, 2018), and teacher experience (Botha et al., 2013). This distribution can be seen in **Figure 6**.

We identified factors affecting mathematical literacy based on a review of 20 articles, categorizing them into two types: internal and external factors. Internal factors influence the quality of mathematical literacy from within the individual. The desire to acquire and process various information initiates the development of mathematical literacy skills, emphasizing the contextual component (OECD, 2021). Therefore, fostering students' reading literacy habits becomes crucial for schools and teachers. In addition to reading habits, the quantity of practicing mathematical problem-solving also influences mathematical literacy. Dewantara et al. (2015) highlighted the importance of increasing mathematical literacy through additional problem-solving practice.

The quantity of this practice is closely related to students' anxiety and self-efficacy, as Bandura's theory suggests that high self-efficacy affects students' success, while low practice quantity leads to high anxiety (Bandura & Watts, 1996).

According to connectionism theory, individual motivation is essential for undertaking any task (Heckhausen & Heckhausen, 2018). To be able to do something, an individual must possess a solid internal stimulus. The connectionism theory asserts that the behavior of every living being is a relationship between stimuli and responses, in this case, motivation (Heckhausen & Heckhausen, 2018). Therefore, student motivation influences the quality of mathematical literacy. Strong motivation and a high quantity of student practice also positively correlate with students' academic performance.

Additionally, good academic performance in mathematics indicates a strong foundation in mathematical skills. Basic mathematical skills are considered one of the indicators of mathematical literacy used in several review articles. Based on individual experiences, as age increases, so does the accumulation of individual experiences. Piaget's (1972) theory also suggests that intelligence changes with a child's growth. Referring to the implementation of PISA is designed for children aged 15 years (OECD, 2021). Various conditions suggest that age influences mathematical literacy. Regarding gender, there are conflicting opinions or findings compared to review articles that claim gender influences mathematical literacy (Almarashdi & Jarrah, 2023). However, a study by Firdaus and Herman (2017) showed that gender does not impact mathematical literacy, as particular abilities cannot be determined by gender.

External factors are those that arise from outside the individual, both from the educational environment and the social community. Teaching and learning go beyond the transfer of knowledge; there is also the transfer of values and skills (Poeck et al., 2018). This results in teachers and the teaching-learning process significantly influencing the knowledge acquired by students. In other words, students' good mathematical literacy skills are derived from the quality of mathematical literacy skills in teachers. This is also evident in implementing the learning process, which involves instructional models and approaches. Research by Warniatun and Junaedi (2019) states that problem-based learning (PBL) model can enhance students' mathematical literacy. In PBL, students directly engage with problems, learn contextual issues, and solve presented problems. Such conditions train students to solve problems related to everyday life, making it a practical application of mathematical literacy. Other conditions indicate that educational facilities such as textbooks and information and communication technology (ICT) impact mathematical literacy. The selection of appropriate textbooks and the integration of ICT as teaching materials engage students in the learning process.

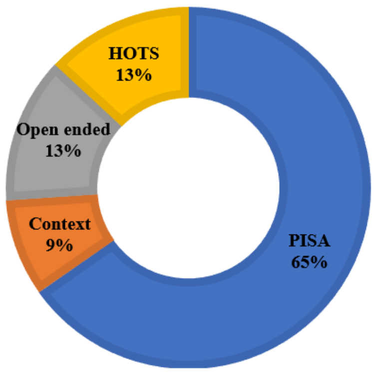

Figure 7. Distribution of mathematical problems (Source: Authors' own elaboration)

Dwijayani (2019) and Muhaimin et al. (2023) argue that attractive learning media can increase student motivation and skills. The role of instructional materials aligns with Dale's cone of experience, a visual model proposed by Edgar (1970). It reveals that the more sensory organs are involved in learning, the better students understand the material. The interconnectedness of culture in mathematics contributes to the contextualization of mathematics (ethnomathematics). Mathematics can be accepted through culture in certain circles, as traditions or cultures strongly connect with daily habits or behaviors (D'Ambrósio, 2005). This situation is consistent with the role of mathematical literacy. Another finding is the factor of human resources, where the meaning of this resource refers to parents and previous educational backgrounds. Preferred schools have better inputs than regular schools due to differences in student admission criteria. Under these conditions, the quality of preferred schools is better, impacting the level of literacy skills. The admission of new students must also be considered regarding the number of available teachers, as this affects the effectiveness of classroom learning, hindering the development of student's abilities, especially in mathematical literacy (Aksu et al., 2017).

RQ4. Mathematical Problems Used to Measure Mathematical Literacy

One of the instruments used to measure mathematical literacy is mathematical problems. Based on Figure 7, there are several types of mathematical problems, and researchers get PISA problems that dominate based on the number of articles used as a research instrument, namely 13 articles (Aksu et al., 2017; Aksu & Guzeller, 2016; Almarashdi & Jarrah, 2023; Altun, 2017; Botha et al., 2013; Dewantara et al., 2015; Hwang & Ham, 2021; Jailani et al., 2020; Kholid et al., 2022; Kusuma et al., 2022; Tapan Broutin et al., 2021; Yenmez & Gokce, 2023; Zainiyah & Marsigit, 2019). Meanwhile, four articles use contextual problems (Fauzi & Chano, 2022; Firdaus & Herman, 2017; Haara, 2018;

Kolar & Hodnik, 2021); two articles use open-ended problems (Kozakli Ulger et al., 2022; Ozgen, 2019), and 1 article uses HOTS problems (Canbazoglu & Tarim, 2020).

Based on the definition of mathematical literacy from OECD, it is necessary to have mathematical problems with compositions to measure these abilities. Problems in literacy generally involve everyday issues (Vasquez, 2014), requiring context for each problem. Marchis (2012) reveals that teachers often present problems involving only mathematical content (routine problems) during the learning process. This results in students' need for more familiarity with mathematical problems, which is one of the causes of low mathematical literacy discussed in the previous topic.

Various types of mathematical problems exist, with PISA problems being the most selected by researchers to measure students' mathematical literacy (see **Figure 7**). This is because PISA problems are tests OECD uses to assess literacy skills globally, encompassing reading, mathematics, and science (Kastberg et al., 2015). In the composition of PISA problems, there are content, context, and processes. This composition indicates that PISA problems can measure mathematical literacy skills, leading many researchers to choose PISA problems for this purpose.

In addition to PISA problems, there are contextual, open-ended, and HOTS problems, which are also considered mathematical problems to measure mathematical literacy skills. In contextual problems, students' experiences are involved in the context of mathematical issues (Widjaja, 2013). The resolution of contextual problems depends on students' understanding of the contextual issues (Laurens et al., 2018). Then, open-ended problems have characteristics, where problem-solving can be done in more than one way, is contextual, and the questions are non-routine (Surya et al., 2020). According to Munroe (2015), open-ended problems are used to train students' strategies in solving non-routine problems. Krathwohl (2008) states that individuals' cognitive levels include remembering, understanding, applying, analyzing, evaluating, and creating. Referring to this statement, HOTS includes the ability to analyze, evaluate, and create (Rosidin et al., 2019). To assess these abilities, problems with context are required (Widana et al., 2019), allowing students to analyze, evaluate, and create. This is supported by Ishartono et al. (2021) statement regarding the characteristics of HOTS problems, one of which requires information in its resolution. Various mathematical problems used to measure students' mathematical literacy have intersections in their components, namely problems that are contextual in nature.

CONCLUSIONS

The importance of mathematical literacy, coupled with the existence of PISA as the program to measure and evaluate literacy skills, has set a research trend in education. This is evident in the abundance of initial articles within the last decade before our review. The distribution of research across countries shows that Turkey has the highest quantity compared to other nations in the review articles (Indonesia, Korea, Saudi Arabia, South Africa, Slovenia, and Norway). The research findings from various review articles indicate that mathematical literacy is still low (95%), and various studies conducted in each country aim to provide solutions to enhance low mathematical literacy in their respective nations.

The review results indicate that research on students' mathematical literacy in solving mathematical problems is still generally low (95%), with Turkey being the most dominant country in this percentage. In solving mathematical problems, the majority of students face difficulties in formulating the problems. Despite having a good conceptual understanding of the material, these difficulties tend to lead to continuous errors, ultimately affecting the accuracy of the obtained conclusions.

Students' excellent or bad mathematical literacy in solving mathematical problems is influenced by two factors: internal factors (emerging from within individuals) and external factors (arising from outside individuals). Internal factors include beliefs, practice quantity, motivation, self-efficacy, anxiety, study discipline, reading literacy habits, academic grades, age, and students' experience in solving mathematical problems. External factors encompass the learning process, student-teacher ratio, learning models, teaching approaches, teacher support, ICT, textbooks, school level, and teacher experience.

Among various mathematical problems, we identified PISA, contextual, open-ended, and HOTS problems used to measure mathematical literacy, with PISA problems dominating the reviewed articles (65%). Although mathematical problems vary in their types, we found common characteristics among each, with mathematical problems being contextual in nature.

Limitations & Recommendations

This research is confined to the selected databases, including articles from ERIC, ProQuest, and Scopus. Furthermore, the selection of articles is limited to the last decade (2013-2023). Another limitation is that the articles are exclusively from journals, focusing on keywords ((“mathematical literacy”) AND (“mathematical problems”) AND (“mathematics education” OR “mathematics”)). Additionally, the findings obtained are still limited, such as the variety of mathematical problems used to measure mathematical literacy, with only four mathematical problems identified. There is a possibility that many other mathematical problems need to be explored and discussed.

The limitations of this research can serve as a foundation for future studies by expanding the research database, extending the timeframe of articles, selecting more articles from proceedings or books, and broadening the focus of research questions. The aim is to strengthen existing theories or discover new ones within the scope of mathematical literacy. Then, from the findings obtained, we have only revealed the difficulties students face in solving mathematical problems, with no alternative solutions identified regarding this issue. Therefore, further research is still available to provide solutions to the identified problems.

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