

Challenges in Developing Mathematical Literacy among Junior High School Students in Aceh, Indonesia

Rini Sulastri^{1*}, Muhamad Saleh¹, Rahmah Johar²

¹Mathematics Education Department, Universitas Serambi Mekkah, Aceh, Indonesia

²Mathematics Education Department, Universitas Syiah Kuala, Aceh, Indonesia

*Corresponding Author: rini.sulastri@serambimekkah.ac.id

Abstract. *Mathematical literacy and numeracy are essential competencies that enable students to solve real-world problems and apply mathematical knowledge meaningfully. Nevertheless, evidence from various assessments indicates that junior high school students in Indonesia still exhibit low levels of mathematical literacy and numeracy. This study aims to explore the underlying causes of these difficulties based on in-depth interviews with teachers and students. The research employed a qualitative descriptive approach and was conducted in three regions of Aceh, Indonesia. Data were collected through semi-structured interviews with junior high school mathematics teachers and students, focusing on learning experiences, instructional practices, and students' engagement with contextual mathematical problems. The findings reveal several key factors contributing to students' low mathematical literacy and numeracy. First, students are not familiar with PISA-type problems that require contextual interpretation, reasoning, and problem-solving skills. Second, mathematics instruction tends to emphasize procedural learning and routine exercises rather than conceptual understanding and real-life applications. Third, learning activities provide limited exposure to contextual and meaningful problems that support literacy and numeracy development. These findings indicate that current instructional practices have not sufficiently supported the development of students' mathematical literacy and numeracy skills. The study underscores the importance of designing learning approaches that promote contextual problem solving and higher-order thinking.*

Keywords: *mathematical literacy, numeracy, PISA-type problems, procedural learning*

1. Introduction

Mathematical literacy and numeracy have become central goals of mathematics education, as they enable students to apply mathematical knowledge to real-life situations, reason mathematically, and make informed decisions. Internationally, mathematical literacy is defined as the capacity to formulate, employ, and interpret mathematics in a variety of contexts (OECD, 2019). These competencies are essential not only for academic achievement but also for students' active participation in social, economic, and civic life.

In Indonesia, the importance of literacy and numeracy has been strongly emphasized through recent national education policies. The implementation of the Asesmen Nasional (AN), with Asesmen Kompetensi Minimum (AKM) as its core component, marks a shift from content-based assessment toward the evaluation of essential competencies, namely literacy and numeracy (Kemdikbudristek, 2021). AKM numeracy focuses on students' ability to reason, solve contextual problems, and apply mathematical concepts across various real-life situations, which closely aligns with the mathematical literacy framework used in PISA (OECD, 2019). This policy shift highlights the urgent need for instructional practices that support students' development of mathematical literacy and numeracy rather than procedural mastery alone.

However, evidence from both international and national assessments indicates that Indonesian students continue to face significant challenges in mathematical literacy. Results from the Programme for International Student Assessment (PISA) consistently show that Indonesian students perform below the OECD average in mathematics literacy (OECD, 2019). Similarly, early findings from the implementation of AKM suggest that many students struggle with numeracy tasks that require interpretation, reasoning, and problem solving in contextual settings (Kemdikbudristek, 2021). These results indicate a gap between the goals of national assessment policies and classroom-level instructional practices.

One factor frequently identified in the literature is the dominance of procedural-oriented instruction in mathematics classrooms, where emphasis on memorization and step-by-step algorithms can overshadow deeper conceptual understanding. Teaching practices that prioritize memorization of formulas and routine exercises tend to foster instrumental understanding rather than conceptual and relational understanding (Skemp, 1976). Consequently, students may succeed in routine tasks but fail to apply their knowledge to unfamiliar or contextual problems, which are central to both PISA and AKM assessments (Hiebert & Grouws, 2007; Kilpatrick et al., 2001).

Several recent empirical studies indicate that students with relatively strong procedural skills often perform well on routine algebraic and arithmetic tasks but experience difficulties when confronted with contextualized or non-routine problems, revealing a gap between procedural fluency and the flexible application of mathematics. Research on students' reasoning in fraction division shows that learners with high procedural knowledge but limited conceptual understanding are able to execute symbolic calculations, yet struggle to solve contextual problems requiring deeper reasoning, whereas students with stronger conceptual understanding demonstrate more adaptive and flexible problem-solving strategies in real-world contexts (Novita et al., 2025). Similar patterns are observed among prospective mathematics teachers, where frequent procedural errors coexist with conceptual misunderstandings, suggesting that instruction heavily oriented toward procedures may inadequately prepare learners for tasks that demand meaningful connections and problem solving (Pratama & Azizah, 2025). Moreover, recent empirical evidence highlights that limitations in teachers' conceptual understanding can shape classroom practices in ways that prioritize procedural routines over deep conceptual engagement. A phenomenological study of elementary teachers' perceptions of number concepts and arithmetic operations revealed persistent difficulties in interpreting and conveying underlying mathematical ideas, which constrained instructional choices and likely influenced students' mathematical understanding and problem-solving abilities (Sulastri & Ardiansari, 2025). Collectively, these findings suggest that an overemphasis on procedural instruction without sufficient conceptual integration can hinder students' ability to transfer mathematical knowledge to unfamiliar or contextual situations—an ability that is central to mathematical literacy and numeracy as emphasized in large-scale assessments such as PISA and AKM.

In response to these challenges, the Indonesian government introduced the Kurikulum Merdeka, which emphasizes student-centered learning, contextual problem solving, and the development of higher-order thinking skills (Kemdikbudristek, 2022). The curriculum encourages teachers to design learning experiences that are meaningful, relevant to students' lives, and supportive of literacy and numeracy development. Nevertheless, several studies indicate that the implementation of such approaches remains limited, particularly in mathematics classrooms, where traditional procedural teaching

practices continue to dominate (Stacey, 2011; Wijaya et al., 2014).

Furthermore, mathematical literacy is closely linked to students' reading comprehension, reasoning, and mathematical modeling skills. Research shows that students often struggle with contextual problems due to difficulties in understanding textual information and translating real-world situations into mathematical representations (Abedi & Lord, 2001; Blum & Leiss, 2007). When assessment practices focus primarily on final answers rather than reasoning processes, opportunities for developing these essential skills become even more limited (OECD, 2019).

Within this policy and instructional context, there is a clear need for qualitative studies that explore the causes of students' low mathematical literacy and numeracy from the perspectives of both teachers and students. Such studies are particularly important in under-researched regions, where contextual and cultural factors may further influence learning practices. Therefore, this study aims to investigate the underlying causes of junior high school students' low mathematical literacy and numeracy through in-depth interviews with teachers and students in three regions of Aceh, Indonesia. The findings are expected to provide empirical insights that support the alignment of classroom practices with the goals of AN, AKM, and the Kurikulum Merdeka, as well as inform the development of contextually grounded and literacy-oriented instructional designs.

2. Method

This study employed a qualitative descriptive research design to explore the underlying causes of junior high school students' low mathematical literacy and numeracy. A qualitative approach was chosen to gain in-depth insights into teachers' and students' perspectives regarding instructional practices, learning experiences, and challenges in solving contextual mathematical problems. This design is appropriate for capturing participants' interpretations and experiences within their natural educational contexts.

The study was conducted in three regions of Aceh, Indonesia, representing diverse geographical and educational settings. Participants consisted of junior high school mathematics teachers and students selected using purposive sampling. The selection criteria for teachers included having experience teaching mathematics at the junior high school level and familiarity with the implementation of national curriculum and assessment policies, such as AKM and the Kurikulum Merdeka. Students were selected based on their willingness to participate and their experience in learning mathematics in regular classroom settings. To ensure ethical considerations, all participants were informed about the purpose of the study, and their participation was voluntary. Anonymity and confidentiality were maintained by using codes (e.g., T1, T2, ... for teachers; S1, S2, ... for students).

Data were collected through semi-structured interviews with teachers and students. The interview protocols were designed to explore participants' experiences with mathematics learning, types of tasks commonly used in classrooms, familiarity with contextual and PISA-type problems, assessment practices, and perceived challenges in developing mathematical literacy and numeracy. Teacher interviews focused on instructional approaches, assessment strategies, curriculum implementation, and perceived student difficulties. Student interviews explored learning experiences, problem-solving strategies, confidence in dealing with contextual problems, and perceptions of mathematics tasks. Each interview lasted approximately 20-45 minutes and was audio-recorded with participants' consent.

The interview data were analyzed using thematic analysis. The analysis followed several stages: (1) familiarization with the data through repeated reading of interview transcripts; (2) initial coding to identify meaningful units related to students' difficulties and instructional practices; (3) grouping codes into broader categories; and (4) generating overarching themes that explain the causes of low mathematical literacy and numeracy. To enhance the credibility of the analysis, coding was conducted iteratively, and emerging themes were continually compared across teacher and student interviews. The final themes were reviewed to ensure consistency and alignment with the research objectives.

Several strategies were employed to ensure the trustworthiness of the study. Credibility was enhanced through data triangulation between teacher and student perspectives. Dependability was supported by maintaining a clear audit trail of data collection and analysis procedures. Confirmability was addressed by grounding interpretations in direct interview excerpts. Transferability was supported by providing detailed descriptions of the research context and participants.

3. Results and Discussions

Analysis of the interview data with mathematics teachers and junior high school students revealed several interconnected factors contributing to students' low mathematical literacy and numeracy. These factors were organized into four main themes.

a. *Unfamiliarity with PISA-Type and Contextual Problems*

Interview data indicate that students' low mathematical literacy and numeracy are strongly related to their unfamiliarity with PISA-type problems. Teachers reported that classroom tasks mainly focus on routine calculations, while contextual and real-world problems are rarely used.

"Students are used to questions that directly ask for calculations. When the problem is presented in a long story or real-life context, they are confused about what is actually being asked." (Teacher T1)

This finding is consistent with the PISA framework, which defines mathematical literacy as the ability to formulate, employ, and interpret mathematics in various contexts (OECD, 2019). Students' difficulty in identifying relevant information and interpreting problem situations suggests limited experience with the formulation stage of mathematical problem solving. Previous studies have shown that students who are rarely exposed to contextual problems tend to perform poorly on literacy-based assessments (Stacey, 2011; Wijaya et al., 2014). A student's statement further confirms this issue:

"If the question is long and related to daily life, I don't know where to start." (Student S3)

b. *Dominance of Procedural-Oriented Instruction*

Another prominent theme emerging from the interviews is the dominance of procedural-oriented instruction. Teachers acknowledged that instructional practices often prioritize demonstrating solution steps to ensure curriculum coverage.

"Most of the time, I explain the steps first, then students follow the same steps." (Teacher T4)

This instructional approach aligns with what Skemp (1976) describes as instrumental understanding, where students learn rules without understanding underlying

concepts. As a result, students rely heavily on memorization and imitation rather than reasoning.

“I usually just remember the formula and follow the steps. If the question is different, I get stuck.” (Student S7)

Research has consistently shown that excessive emphasis on procedures limits students’ ability to transfer knowledge to new and unfamiliar situations (Hiebert & Grouws, 2007; Kilpatrick et al., 2001), which is a critical requirement for mathematical literacy and numeracy. Recent research continues to confirm this perspective, showing that instruction emphasizing conceptual understanding, multiple representations, and problem solving in non-routine contexts leads to stronger knowledge transfer and higher levels of mathematical literacy than procedure-focused teaching alone (Schukajlow et al., 2021). Large-scale evidence from PISA 2022 further underscores that mathematical literacy requires the ability to apply mathematics flexibly in unfamiliar real-world situations, rather than merely executing learned procedures (OECD, 2023).

c. *Limited Reasoning, Modeling, and Reading Comprehension Skills*

The interviews also revealed that students struggle with mathematical reasoning, modeling, and reading comprehension. Teachers emphasized that many students fail at the initial stage of understanding the problem rather than at performing calculations.

“Students often fail not because they cannot calculate, but because they do not understand the meaning of the problem.” (Teacher T2)

This finding supports Schoenfeld’s (1985) argument that successful problem solving depends on sense-making and strategic reasoning, not merely computational skills. Furthermore, mathematical literacy requires students to translate real-world situations into mathematical representations, a process known as mathematical modeling (Blum & Leiss, 2007).

“I don’t understand how the story in the problem becomes a math equation.” (Student S1)

Similar difficulties have been reported in previous studies, indicating that weak reading comprehension and modeling skills are significant barriers to students’ mathematical literacy development (Abedi & Lord, 2001; Stacey, 2011).

d. *Assessment Practices and Affective Factors*

Assessment practices emerged as another contributing factor. Teachers reported that evaluations mainly focus on final answers rather than reasoning processes.

“In tests, we mainly check whether the final answer is correct, not the process.” (Teacher T3)

This practice contradicts recommendations from literacy-oriented assessment frameworks, which emphasize reasoning, explanation, and interpretation (OECD, 2019). Such assessment practices reinforce procedural learning and discourage students from engaging in deeper thinking. In addition, affective factors such as low confidence and anxiety were evident in students’ responses.

“I feel nervous when the question is not similar to the example.” (Student S4)

Previous research has shown that students' beliefs and emotions toward mathematics significantly influence their willingness to engage with non-routine problems (Hannula, 2012). Low confidence further limits students' persistence in solving complex contextual tasks.

e. *Synthesis of Findings*

Overall, the findings suggest that students' low mathematical literacy and numeracy are the result of interconnected instructional, cognitive, and affective factors. The dominance of procedural teaching, limited exposure to contextual and PISA-type problems, weak reasoning and modeling skills, assessment practices focused on final answers, and low student confidence collectively hinder students' ability to apply mathematics meaningfully.

These results are consistent with prior studies emphasizing the need for instructional shifts toward contextual, problem-based, and reasoning-oriented mathematics learning (Hiebert & Grouws, 2007; Stacey, 2011; OECD, 2019). The findings provide a strong empirical foundation for the development of didactical designs that integrate contextual problems and support students' mathematical literacy.

4. Conclusions

This study examined the challenges in developing mathematical literacy among junior high school students in Aceh, Indonesia, based on interviews with teachers and students. The findings show that students' low mathematical literacy is mainly influenced by instructional practices that emphasize procedural learning and routine tasks, resulting in students' unfamiliarity with PISA-type, contextual problems. In addition, limited reading comprehension, weak reasoning and modeling skills, assessment practices focused on final answers, and low student confidence further hinder students' performance in mathematical literacy tasks. These challenges indicate a misalignment between classroom practices and the objectives of literacy-oriented assessments such as PISA and AKM. The study highlights the need for instructional approaches that prioritize contextual problem solving, reasoning, and mathematical communication to support the development of students' mathematical literacy.

5. Acknowledgements

The authors would like to express their sincere gratitude to Direktorat Riset, Teknologi, dan Pengabdian kepada Masyarakat (DRTPM), Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia for the financial support provided through the Fundamental Research Grant in 2025. The authors also thank the participating schools, teachers, and students in Aceh for their cooperation and valuable contributions to this study.

6. References

- Abedi, J., & Lord, C. (2001). The language factor in mathematics tests. *Applied Measurement in Education*, 14(3), 219–234.
- Blum, W., & Leiss, D. (2007). *How do students and teachers deal with modeling problems?* In C. Haines et al. (Eds.), *Mathematical Modelling*. Springer.
- Hannula, M. S. (2012). Exploring new dimensions of mathematics-related affect. *Research in Mathematics Education*, 14(2), 137–161.

- Hiebert, J., & Grouws, D. A. (2007). *The effects of classroom mathematics teaching on students' learning*. In F. K. Lester (Ed.), *Second Handbook of Research on Mathematics Teaching and Learning*.
- Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi (Kemdikbudristek). (2021). *Asesmen Nasional: Laporan kebijakan*. Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia.
- Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi (Kemdikbudristek). (2022). *Kurikulum Merdeka: Kerangka dasar*. Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia.
- Kilpatrick, J., Swafford, J., & Findell, B. (2001). *Adding It Up: Helping Children Learn Mathematics*. National Academy Press.
- Novita, R., Putra, M., Usman, & Junita, S. (2025). Conceptual and procedural knowledge in students' fraction division thinking: Insights from a hermeneutic phenomenological study. *Journal on Mathematics Education*, 16(4), 1233–1256. <https://doi.org/10.22342/jme.v16i4.pp1233-1256>
- OECD. (2019). *PISA 2018 Assessment and Analytical Framework: Mathematics*. OECD Publishing.
- OECD. (2023). *PISA 2022 assessment and analytical framework*. OECD Publishing.
- Pratama, D., & Azizah, N. (2025). Analyzing conceptual and procedural errors in solving routine problems on gradients and straight-line equations among prospective mathematics teachers. *Journal of Didactic Mathematics*, 6(2). <https://doi.org/10.34007/jdm.v6i2.2722>
- Schoenfeld, A. H. (1985). *Mathematical Problem Solving*. Academic Press.
- Skemp, R. R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching*, 77, 20–26.
- Schukajlow, S., Kaiser, G., & Stillman, G. (2021). Modeling from a cognitive perspective: theoretical considerations and empirical contributions. *Mathematical Thinking and Learning*, 25(3), 259–269. <https://doi.org/10.1080/10986065.2021.2012631>
- Stacey, K. (2011). The PISA view of mathematical literacy in Indonesia. *Journal on Mathematics Education*, 2(2), 95–126.
- Sulastri, R., & Ardiansari, L. (2025). Teachers' perceptions of number concepts and arithmetic operations in elementary education. *Jurnal Didaktik Matematika*, 12(1), 36–52. <https://doi.org/10.24815/jdm.v12i1.42379>
- Wijaya, A., van den Heuvel-Panhuizen, M., & Doorman, M. (2014). Opportunity-to-learn context-based tasks. *Educational Studies in Mathematics*, 86, 49–65.