Jurnal Review Pendidikan Dasar:
Jurnal Kajian Pendidikan dan Hasil Penelitian
Vol 11(3), Oktober 2025

e-ISSN: 2460-8475
http://journal.unesa.ac.id/index.php/PD
https://doi.org/10.26740/jrpd.v11n2.p373-388

Student Misconceptions in Elementary School When Solving Problems on Mathematical-Literacy-Based Question Types

Firstlyta Bulan Aulya Ahmad✉, Universitas Negeri Surabaya

Alifatul Hidayah, Universitas Negeri Surabaya

Zaenal Abidin, Universitas Negeri Surabaya

corresponding author: ✉ *firstlytabulan@gmail.com*

Abstract: The purpose of this study is to characterizes the challenges that students encounter when attempting to solve mathematical literacy problems. Indonesia's disappointing performance on PISA 2022 assessment, scoring roughly 366 well below the OECD average reflects how misconceptions surrounding fundamental mathematical concepts continue to pose a significant challenge, especially among elementary school students. The study involved Grade 5, Phase C students who had already covered the relevant material and were subsequently given literacy-based mathematics problems across two testing phases: an initial phase designed to pinpoint students' core difficulties, followed by a second phase intended to confirm the researchers' preliminary analysis. Data were examined through a descriptive qualitative approach, with findings interpreted using misconception indicators drawn from established expert frameworks. To support the written assessments, the researchers conducted informal interviews while students worked through the problems, and these conversations corroborated the patterns observed in the test results. The analysis revealed that students' primary struggles stemmed from misconceptions occurring across the formulating, employing, and interpreting stages of problem-solving. Errors were most concentrated in the employing stage, 50% of all mistakes finding that led the researchers to recommend a structured, context-driven instructional approach combined with Problem-Based Learning (PBL) to strengthen students' mathematical literacy.

Keywords: Mathematical literacy, Misconception, Context, Structured, PBL

How to Cite: Ahmad, F.B.A., Hidayah, A., & Abidin, Z. (2025). Student Misconceptions in Elementary School When Solving Problems on Mathematical-Literacy-Based Question Types. *Jurnal Review Pendidikan Dasar: Jurnal Kajian Pendidikan dan Hasil Penelitian, 11*(3), 373-388. https://doi.org/10.26740/jrpd.v11n3.p373-388

Article Info:
Received: 29 June 2025; Accepted: 14 September 2025; Published Online: 28 October 2025

Published by:
Pendidikan Dasar Universitas Negeri Surabaya

INTRODUCTION

Mathematical literacy is a core competency that students must master. Mathematical literacy teaches how to identify, understand, and use mathematics in topics both inside and outside the classroom (Yulius & Zainil, 2025). Given how important the ability of mathematical literacy is, it stands to reason that many countries should have adequate mathematical literacy scores. However, data show that many countries still have mathematics literacy scores below average. Gaiger, as cited in Bolstad (2021), states that "Mathematical literacy (ML) is a notion used to define the body of knowledge and competences required to meet the mathematical demands of personal and social life and to participate in society as an informed, reflective, and contributing citizen." Based on this explanation, mathematical literacy can be defined as the ability to interpret mathematical problems within everyday contexts.

The latest data from PISA 2022 (Program for International Student Assessment) 2022 show the mathematical literacy results of students from various parts of the world (PISA 2022). A total of 81 countries were tested, including Indonesia. Indonesia itself falls into the category of countries with mathematical literacy scores below average. Indonesia's score stands at 366, which is far below the OECD average of 472. Equally concerning is the percentage of Indonesian students whose ability falls below standard (level 2), which reaches 71,8%. In other words, 7 out of 10 students have mathematical literacy skills below average. This finding is a key indication that difficulty in understanding mathematical concepts remains widespread and systemic.

This global survey data is consistent with the results of the pretest conducted by researchers on elementary school students. The pretest result showed that only 3 out of 15 students were able to answer the question correctly and coherently. Some students exhibited a similar tendency: understanding the problem procedurally but making errors in translating the context, misidentifying important in students' understanding of basic mathematical concepts. These findings are consistent with the study by Saaroh et al. (2021), which reported that mathematical misconceptions are characterized by students' inability to translate contextual problems into mathematical representations, identify the appropriate concepts, and select appropriate strategies or operations to solve mathematical problems.

The misconceptions experienced by students are largely apparent in their process of understanding concepts, meaning, and mathematical representation. According to Kose, as cited in Muhlisa (2021), misconceptions occur when there is a discrepancy between an individual's conceptual understanding and the scientific concept. This means that students make errors in interpreting the intenseness of a problem, which then leads to mistakes in deciding how to solve it. Several studies use problems involving geometry and algebra, as these are considered to be where the most errors/misconceptions in comprehension occur. Insufficient conceptual understanding is one of the factors that contributes to the development of misconceptions among students (Sadiah & Afriansyah, 2023). Such problems are basic questions that often involve unit conversion, proportional reasoning, tables, and graphs, which then impact errors in solving mathematical-literacy-based problems.

This issue confirm that mathematical literacy ability is determined not only by mastery of formulas but also by a correct grasp of basic concept (Zukhrufurrohmah & Putri, 2021). In 2021, a national assessment consisting of the AKM, a character survey, and a learning environment survey was introduced to replace the national examination. In this assessment, students are presented with contextual literacy-based problems using more complex language and terminology, requiring them to be able to understand and reason correctly. Students who remain trapped in misconception will have difficulty completion the AKM, which is essentially a national test, because they will be unable to correlate mathematical concepts with everyday life contexts. This condition further underscores the need for early, and remediation of misconceptions starting from the elementary school level.

Unlike previous studies, which generally only used a pretest and posttest to measure short-term learning gains, this study applies to two diagnostic testing stages with different functions and a longer time span between them. Essay-type questions were used instead of multiple-choice questions to avoid students guessing the answer, since a selected answer choice would be less representative of the students' actual ability (Sakahuni & Ramadhanti, 2021). In the first test, the instrument was specifically designed to identify students' main difficulties in answering literacy-based problems. Subsequently, a second test was administered using similar problems but focused on the misconceptions identified earlier, in order to examine the consistency and robustness of students' conceptual understanding. This approach enables an analysis of whether misconceptions hinder the process of understanding context, grasping concepts, and determining the appropriate operation in mathematical literacy problems. This finding is consistent with the study by Amalia and Putri (2025), which showed that students with misconceptions then to experience difficulties in interpreting the context of mathematical problems, relating information to mathematical models, and selecting appropriate operations based on the given problem context. With an interval of approximately one month between the two tests, this study also provides a picture of the stability of students' understanding over time, thereby offering a more comprehensive perspective than previous studies that only assessed performance at a single point in time.

Based on the above conditions, in which many students still experience misconceptions on basic problem types, this study becomes important to conduct to identify the forms of misconception among elementary school students in solving mathematical-literacy-based problems. By understanding the pattern of errors and the sources of misconceptions, the findings can serve as input and evaluation material for teachers in designing more appropriate learning strategies in the future. In addition, the results of this study are expected to contribute to efforts to improve the mathematical literacy of Indonesian students so that they can meet the demands of PISA, the AKM, and the needs of 21st-century learning.

METHODS

This Study uses a qualitative descriptive approach to identify and describe the misconceptions of elementary school describe the misconception of elementary school student in solving mathematical literacy problems on the topics of geometry and fractions. Through two complementary testing stages, the researchers explored student’s thinking patterns to understand how misconception forms and influence their responses. This approach aligns with Suparno’s perspective on misconception in his book Misconception and Conceptual Change in Physics Education (2013), which states that a misconception occurs when a student’s understanding is inaccurate and tends to persist strongly even after the correct concept has been taught.

The research subjects consisted of 15 students who had already studied plane figures and fractions. The first test aimed to identify students’ initial difficulties and found that the main obstacle lay not in the literacy context but in conceptual and procedural misconceptions. This finding then became the basis for designing the second test, which was intended to bring out the misconceptions more clearly by emphasizing the concepts that had previously caused problems.

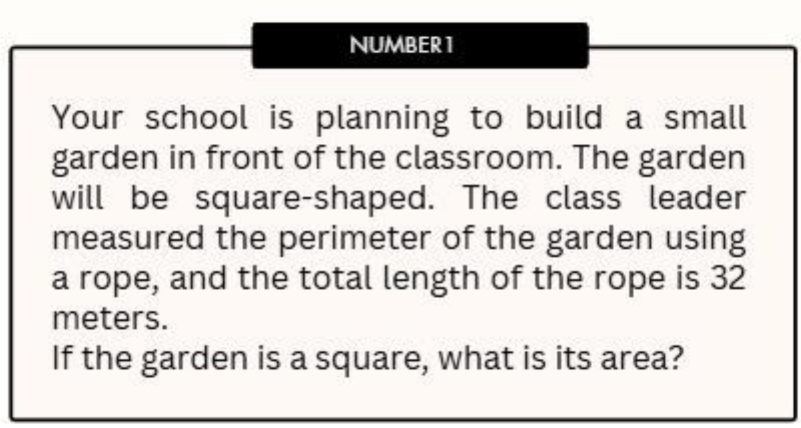
In addition to using written test instruments, the researchers also conducted implicit interviews during the problem-solving process by posing probing questions to the students. These questions focused on the students' reasons for choosing a particular answer, their considerations in determining which operation to use, and their reasons for not using an alternative strategy or method. This approach is consistent with the think-aloud technique and probing questions used to explore subjects' thought processes in depth during problem-solving. The interview data were used as supporting data in the analysis of research results to strengthen the classification of error factors and student misconceptions in solving mathematical literacy problems (Ericsson & Simon, 1993).

The results of the second test showed that roughly half of the students were able to answer correctly, while the rest still exhibited misconceptions consistent with the initial findings. The data were analyzed using several indicators, leading to conclusions drawn with a misconception in understanding mathematical literacy problems, which serve as a basis for recommendations to improve mathematical literacy instruction in the future.

RESULTS

This section presents the findings obtained during the testing process concerning the problems experienced by students in answering mathematical-literacy-based questions. To obtain a clearer picture, the analysis focuses on the main factor, namely misconception. Understanding of the problem is a highly crucial aspect, as comprehension does not only determine whether a student's answer is correct or incorrect, but also reflects how deeply the student is able to grasp and apply mathematical material/concepts in everyday life.

The researchers administered two problems to the students, drawn from the same class and the same subjects as in the pretest. The first problem is a mathematical literacy question dealing with introductory geometry material, namely the recognition of plane figures. The problem was presented as a scenario commonly encountered in everyday life, with the aim of determining the extent of students' ability to solve such contextual problems.


NUMBER 1

Your school is planning to build a small garden in front of the classroom. The garden will be square-shaped. The class leader measured the perimeter of the garden using a rope, and the total length of the rope is 32 meters.
If the garden is a square, what is its area?

Figure 1. Geometry Problem

This problem was designed based on an analysis of the mathematics textbooks used at the elementary school level. In addition, the problem was designed to test the misconception that frequently occurs among students, particularly their difficulty in distinguishing between a square and a rectangle.

During the problem-solving process, the researchers also engaged in dialogue with the students to gather information that could deepen the research findings. Some of the questions posed included the following:

"Is this drawing of a square, correct?"

"What other examples of squares are there in this classroom? Are there any?"

"In your opinion, does the whiteboard count as a square? Why?"

Based on the results of this dialogue, most students gave the following answers:

1. A square is understood as a shape that has four sides, without regard to whether the sides are equal in length, or the angles are equal in size.
2. Students were confused and unable to give an example of a square found in the classroom.
3. Students stated that the whiteboard is a square because it has four sides.

The second problem deals with number/quantity material. This topic was chosen after the researchers analyzed the mathematics problems used at the elementary school level, finding that number material is among the topics with a high rate of misconception among students.

Number material is abstract and challenging in nature. Many students are able to solve simple arithmetic operations, such as 2 + 2 = 4. However, when this concept is embedded in a literacy-based or contextual problem, students tend to have difficulty understanding and solving it. The following is the problem designed by the researchers concerning this number of materials.

NUMBER 2

A mother has a piece of fabric with an area of 1 square meter. She uses 2/3 of the fabric to make a tablecloth. Then, only 3/4 of the fabric used for the tablecloth is decorated with lace.
How much of the fabric (in square meters) is decorated with lace?

Figure 2. Number Problem

The dialogue between the researchers and the students reinforced these findings and was consistent with the students' written answers on the answer sheets. The dialogue showed that students tended to skim the problem without carefully examining the meaning of the keywords that determine the direction of the solution. This finding is presented in the table below.

The following table presents the misconceptions identified in the students' answers as research subjects. The misconception indicators are based on an analysis of two well-known theories, namely Dahar and .... These indicators were then mapped into a misconception table containing the type, the presumed cause, and concrete evidence from the students' answers.

Table 1. Results and Analysis of Student Answers

No	Type of Misconception	Student's Answer	Presumed Root Cause
1	Incorrect concept of shape	Student drew a rectangle instead of a square	1. Does not understand that a square, by definition, has all sides equal in length. 2. Accustomed to drawing rectangles in everyday life.
2	Applying the wrong formula	Student found the correct side length but computed the area using the perimeter formula (A = 4 × side)	1. Confused between the concepts of perimeter and area. 2. Assumed every square formula uses 4 × side.

3	Direct calculation using perimeter	Student directly multiplied the perimeter without first finding the side length	Does not understand the relationship between perimeter, side length, and area.
4	Summing perimeter lengths	Student added the perimeter figures in an attempt to find the area	Does not understand that area refers to a surface (region), not a length.
5	Choosing the wrong operation	Student used subtraction for a step that should have used multiplication	Does not understand the keyword "of" ("dari") as indicating multiplication.
6	Equalizing denominators before multiplying fractions	Student equalized the denominators before multiplying the fractions	Assumed that every fraction operation requires equalizing the denominators.
7	Cross-multiplying and then adding	Student applied a cross-multiplication pattern and then added the results	1. Misunderstood the cross-multiplication procedure. 2. Does not understand the structure of fractions.
8	Inventing a personal rule / miscalculating the result	Student cross-multiplied the fractions and wrote the result as a single combined number (tens and units)	Does not understand the concept of the operation involved, leading the student to invent a personal rule instead of following the correct procedure.

Based on the analysis of students' answers presented in the table, students' greatest difficulty in solving mathematical-literacy-based problems occurs at the employing stage (using the appropriate concept or formula). Students tend to use the perimeter formula without further understanding the intent of the problem. This error occurred quite frequently among the students tested, for example calculating area using the perimeter formula, being unable to determine the side length, and using the wrong arithmetic operation for fractions. This finding provides strong evidence that students still experience significant obstacles with the basic, contextual concepts underlying mathematical literacy problems.

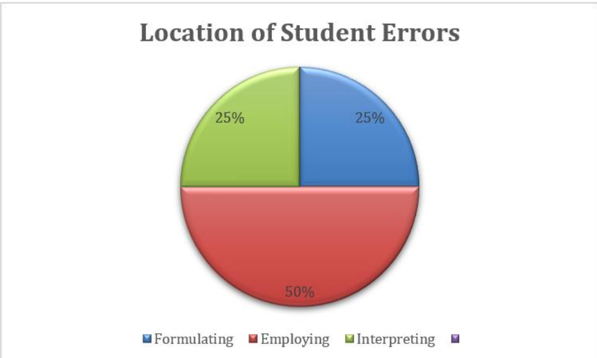


Figure 3. Diagram of the Location of Student Errors

Although most student errors occur at the employing stage, some students also experienced difficulties at the formulating and interpreting stages. Students identified as having difficulty at the formulating stage (25%) tended to make errors in drawing the shape of a square. They regarded any plane figure with four sides as a square, causing many of them to draw a square as a rectangle instead. In several cases encountered, the researchers had already prompted the students with questions about the properties of plane figures. However, some of them remained firmly convinced that a rectangle and a square are the same shape.

The researchers also found obstacles at the interpreting stage, amounting to 25%. These students had been able to understand the intent of the problem and identify the appropriate formula, yet the difficulty arose at the stage of computation and writing the result. When the researchers asked clarifying questions about the origin of the results the students had written, the students still defended their answers and explained that their calculation method had been correct. This is strong evidence that students experience not only procedural obstacles but also interpretive ones (reinterpretation). This finding at this stage shows that conceptual and formulaic understanding alone does not automatically enable students to correctly interpret their results.

DISCUSSION

Geometry is one of the fundamental topics in mathematics learning that is very closely tied to everyday life. Various geometric shapes are actually frequently encountered in daily activities, though they often appear in hidden or implicit ways. Most students are unable to apply their understanding of mathematical problems to everyday life, and there are still students who cannot comprehend word problems, leaving them confused when working on such problems (Selviani et al., 2021). Nevertheless, the close connection between geometry and real life has not been fully utilized in classroom instruction.

(Majoni, 2017) conducted a study on the impact of curriculum overload on teacher performance, finding that teachers were unable to prepare quality instruction for students, and that students were unable to grasp difficult concepts more deeply. This is a case frequently found in Indonesia, where teachers tend only to explain mathematical concepts at a surface level, without following up with a deeper understanding of the concept, such as its implementation in daily life, its function, or the origin of how the mathematical concept was formed. This condition is influenced by limited instructional time, and the large number of subjects students must take, meaning each topic cannot be absorbed deeply and thoroughly. OECD (2020) explains that a dense curriculum, or “curriculum overload,” can create various pressures for a range of groups.

This finding is consistent with students' responses stating that “a square and a rectangle are the same because they both have four sides.” This statement is not entirely wrong, since hierarchically a square can be categorized as a special case of a rectangle. However, this only holds true provided that opposite sides are equal in length, and all four angles are right angles (90 degrees). If this condition is disregarded, various other plane figures, such as parallelograms, rhombuses, and even trapezoids, could mistakenly be classified as squares.

A square itself is defined as a plane figure with four sides of equal length and four angles of equal measure, namely 90 degrees. Students can logically order the properties of shapes; for instance, a student may state that a square is also a rhombus, and a rhombus is also a parallelogram (Umami et al., 2020). If equal side length is treated as the sole criterion without regard to angle measure, the concept of a square will overlap with the concept of a rhombus. This is one of the main causes of students' confusion in understanding the concept of plane figures. When a foundational conceptual understanding has not been properly established, misunderstanding will continue into subsequent topics.

This is crucial because the ability to comprehend is the initial stage in the study of mathematical literacy. (Mailani et al., 2024) Understanding basic geometric concepts helps students think logically and analytically. Students' inability at the comprehension stage will directly affect their ability to apply, reason, and solve mathematical problems within real-life contexts.

In addition to conceptual understanding, a key factor in solving mathematical literacy problems is students' ability to identify important information contained within the problem. Mathematical literacy problems are generally presented in narrative contexts containing specific keywords that indicate what is being asked and which mathematical operation should be used (Irwan & Oktafiani, 2021). In the study by Fitri et al. (2022), Jha (2012, p. 18) states that a comprehension error is a type of error made by students when they can read a problem well but fail to understand its intended meaning. Students who read without understanding will be unable to identify the purpose of the passage. Students' inability to recognize important information is one of the main obstacles preventing them from fully understanding the intent of a problem. This difficulty factor causes students to be unable to properly determine the relevant information contained in a problem (Fitry et al., 2022).

This is evident in the second problem, which asks students to determine a portion of a fraction. In this problem, there is a keyword, "of", which mathematically implies the use of multiplication. However, some students were not yet able to interpret this keyword as an indicator of the operation to use, resulting in difficulty determining the correct problem-solving steps. (Putri et al., 2025) An inability to understand the conceptual basis of a procedure causes students to make mechanical errors, such as selecting the wrong arithmetic operation. As a result, students not only make computational errors but also misunderstand what the problem is actually asking.

Keywords in mathematical literacy problems play an important role as a bridge between everyday language and mathematical representation. Interpretive comprehension, indicated by a student's ability to understand the meaning/intent of a problem, is achieved when the subject is able to grasp the intended meaning of the given problem (Cahyanti et al., 2025). When students are unable to interpret these words into the appropriate mathematical concept or operation, the process of understanding the problem is hindered. This condition shows that the obstacles experienced by students are not solely related to computational aspects, but also to the ability to understand mathematical language within the context of a problem. (Mahfudiah, 2022) Students merely apply an existing concept but are unable to interpret it within a mathematical context.

These findings are consistent with the views of previous researchers explaining that misconceptions are frequently found in literacy-based problems. (Ira & Wiryanto, 2021) Students have limited ability to understand the meaning of word problems, which frequently leads to misconceptions on story-problem material. A similar pattern was found in the 2022 PISA report, which noted the low reading scores of Indonesian students. Based on both theories combined with the data from the table, it is evident that procedural errors are caused not only by a lack of knowledge of formulas but also by an inability to understand context. This is consistent with (Hayati & Jannah, 2024), which states that mathematical literacy ability is not only related to computational skill but also to problem-solving ability, logical reasoning, and critical reasoning This is consistent with (Hayati & Jannah, 2024), which states that mathematical literacy ability is not only related to computational skill but also to problem-solving ability, logical reasoning, and critical reasoning. Student errors in solving numeracy problems often stem not only from cognitive limitations but also from low metacognitive awareness regarding the planning, monitoring, and evaluation of thought processes (Listiyani, Fitriani, Apsob, & Sugiri, 2026).

This condition shows that the obstacles experienced by students are not solely related to computational aspects, but also to the ability to understand mathematical language within the context of a problem (Safitri, Nuriman, Alfarisi, & Setya, 2024). Mahfudiah (2022) Students merely apply an existing concept but are unable to interpret it within a mathematical context. Teachers must have the right and effective approach when teaching mathematics so that the material can be properly understood by students (Samosir et al., 2022) To improve mathematical literacy ability, efforts are needed to develop it within the learning process. Based on the analysis, a learning strategy that is more structured and more focused on the context of mathematical literacy problems was identified. Teachers need to guide students to understand the context before applying a particular formula, since understanding the context is a crucial point in mathematical literacy problems. Once students correctly understand the context, they will find it easier to select the appropriate problem-solving procedure (formula, strategy, and mathematical model). One method that can be used is structured learning, beginning with reading, identifying important information, understanding the intent/question being asked, and finally selecting the appropriate method of solution. This method minimizes student errors at the formulating, employing, and interpreting stages.

In addition to a structured learning model, teachers can also use a Problem-Based Learning (PBL) approach, which generally trains students to understand problems, identify information, and find solutions through a variety of processes. Combining structured learning with PBL will help create a more meaningful and comprehensive learning environment.

CONCLUSION

Based on the results of observation and analysis of students’ answers to mathematicial literacy problems, it can be concluded that students experience significant difficulty in solving mathematical literacy problems due to misconceptions at the formulating, employing, and interpreting stages. Although the contextual problem format does not rule out the fact that many students still have difficulty grasping the intended meaning and finding relevant information, some students also had not yet mastered the procedural stage of computation.

This difficulty is most likely influenced by a lack of understanding of both context and certain mathematical concepts. Students' tendency to memorize formulas without understanding the reasoning behind their use also contributes to their inability to solve mathematical literacy problems.

Overall, this study underscores the importance of focused and structured learning. Structured learning allows for gradual contextual practice, which deepens students’ abilities while also minimizing errors at every stage of solving mathematical literacy problems. Accordingly, improvements in students’ mathematical literacy can be achieved through a structured learning approach.

Following these findings, educators are encouraged to transform their classroom teaching strategies by placing greater emphasis on the process of reasoning and understanding rather than solely on the result. Teachers must be able to detect misconceptions early by giving students room to explain their thought processes, both verbally and in writing, rather than merely assigning repetitive tasks. The use of learning models such as Problem-Based Learning (PBL) should be optimized to sharpen students' mathematical literacy in analyzing information, identifying relevant data, and independently constructing accurate mathematical models. In addition, policymakers at the education-unit level need to integrate curricula that strengthen literacy, given that reading ability and language logic are fundamental prerequisites before students can properly engage in mathematical literacy. Schools are also encouraged to facilitate the development of more varied teaching materials rich in local context, so that students become accustomed to viewing mathematics as a living, relevant tool in their daily lives rather than merely a collection of abstracts, tedious formulas. This study could be further expanded by exploring pedagogical interventions designed to remediate misconceptions in mathematical topics with a higher degree of literacy complexity, as well as by examining the influence of mathematics anxiety on students' ability to critically interpret solutions. With a combination of improved teaching methods and the provision of appropriate learning instruments, it is hoped that these misconception-related obstacles can be minimized, allowing Indonesian students' mathematical literacy to develop more optimally in the future.

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