

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

Firstlyta Bulan Aulya Ahmad✉, State University of Surabaya, Indonesia

Alifatul Hidayah, State University of Surabaya, Indonesia

Zaenal Abidin, State University of Surabaya, Indonesia

✉ firstlytabulan@gmail.com

Abstract: Existing studies have examined context-based mathematical errors and topic-specific misconceptions, while less attention has been given to their distribution across mathematical literacy processes and their persistence over time. This study examines misconceptions among 15 Grade 5 students when solving mathematical literacy problems involving plane figures and fractions. A descriptive qualitative design was employed using two written tests administered approximately one month apart and probing questions during problem solving. Students' responses were classified according to the *formulating*, *employing*, and *interpreting* processes. Eight types of misconceptions were identified. Half of the identified errors occurred in the *employing* process, while the *formulating* and *interpreting* processes each accounted for one quarter. In the second test, approximately half of the students answered correctly, while the remaining students displayed misconceptions consistent with those identified previously. The findings highlight the need for explicit instruction on shape properties, formula selection, keyword interpretation, and result verification. A structured, context-first learning sequence incorporating Problem-Based Learning warrants further empirical investigation.

Keywords: Mathematical Literacy; Misconceptions; Plane Figures; Fractions; Problem-Based Learning

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>

© The Author(s) 2025

Article Info:

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

INTRODUCTION

Mathematical literacy involves using mathematical knowledge to address real-world situations. Stacey (2011) described the Programme for International Student Assessment (PISA) as an assessment of how 15-year-olds apply school knowledge and skills to real-world tasks. Blum and Niss (1991) similarly discussed mathematical modelling and applications as links between mathematics instruction and other subjects. Accordingly, this study examines mathematical literacy through three processes: *formulating* situations mathematically, *employing* mathematical concepts and procedures, and *interpreting* results in context.

Concern about Indonesian students' mathematical literacy has continued in recent years. Recent evidence indicates that Indonesia's PISA mathematics score declined by 13 points between 2018 and 2022 (Wijaya et al., 2024). In an interview study with 36 Indonesian mathematics teachers, Wijaya et al. (2024) reported that the teachers attributed the decline to pandemic-related issues, curriculum, individual factors, resource limitations, student factors, and parental involvement. National indicators of this kind describe overall performance. They do not show which ideas students hold while solving a problem, and this information is needed for instructional decisions at the classroom level.

Previous studies have identified difficulties in interpreting contexts and translating word problems into mathematical representations. Wijaya et al. (2014) found that 38% of errors on released PISA mathematics tasks concerned contextual understanding and 42% concerned mathematical transformation. Verschaffel et al. (2020) reviewed the role of word problems in connecting school mathematics with real-world situations. Vilenius-Tuohimaa et al. (2008) reported an association between reading comprehension and mathematical word-problem performance, while Hegarty et al. (1995) found that unsuccessful solvers tended to translate numbers and keywords directly rather than construct a model of the situation.

Research on specific mathematical topics has also documented persistent misconceptions. Fujita (2012) examined learners' difficulties with quadrilateral inclusion relations and prototype figures. Tan Şişman and Aksu (2016) identified misconceptions in spatial measurement, including confusion between area and perimeter formulas. In fraction arithmetic, Siegler and Pyke (2013) found that fraction magnitude knowledge

and whole-number division predicted performance, while Braithwaite et al. (2019) documented continuing difficulties with fraction arithmetic.

Previous research has examined context-based errors, topic-specific misconceptions, and the language demands of mathematical word problems. However, limited attention has been directed toward the distribution of misconceptions across the *formulating*, *employing*, and *interpreting* processes when students solve problems involving both geometry and fractions. Research also remains limited regarding whether similar misconceptions persist when students encounter comparable problems at a later time, particularly in Indonesian primary schools. This study examines misconceptions in Grade 5 students' solutions to mathematical literacy problems involving plane figures and fractions. Two diagnostic written tests were administered approximately one month apart, supplemented by probing questions during problem solving. Specifically, the study addresses the following research questions: 1) What types of misconceptions appear in students' solutions? 2) How are these misconceptions distributed across the three mathematical literacy processes? 3) Whether and how do the misconceptions remain evident in the second test? The study provides a descriptive account of one classroom and does not evaluate an instructional intervention. A misconception is understood as a student's conception that differs from the accepted mathematical concept and tends to persist after instruction. Smith et al. (1994) argued that students' prior conceptions can be flawed while also serving as productive resources for learning. This perspective informs the analysis of students' written answers and expressed reasoning.

METHODS

Research design

A descriptive qualitative design was used to characterize Grade 5 students' misconceptions through written responses and spoken explanations. Sandelowski (2000) described qualitative description as an approach that presents events in terms close to participants' accounts. This design supported the detailed examination of students' reasoning within one classroom without testing hypotheses or evaluating an instructional intervention.

The participants were 15 Grade 5 (Phase C) students from one class who had studied plane figures and fractions. The same students completed both tests, enabling a descriptive comparison of their responses across two occasions. School identity and

additional demographic details are not reported.

Instruments

Two written essay tests were administered, each containing two mathematical literacy problems in everyday contexts. Constructed-response tasks were used to make students' solution steps and reasoning visible, consistent with the approach described by Tan Şişman and Aksu (2016). The first problem concerned plane figures and required students to draw a square, determine its side length, and calculate its area (Figure 1). It targeted difficulties in distinguishing a square from a rectangle. The second problem concerned fractions and required students to determine a fractional portion (Figure 2). The keyword "of" (*dari*) was included to examine students' interpretation of multiplication in context.

The second test was administered approximately one month later and used similar problems emphasizing concepts that had caused difficulty in the first test. During both problem-solving activities, researchers posed informal probing questions about students' answers, operation choices, and alternative strategies. These dialogues supplemented the written responses by clarifying students' reasoning and supporting the classification of misconceptions. Fox et al. (2011) discussed how verbal reporting procedures may influence performance; this possibility is considered in the study's limitations.

Data analysis

Students' written answers were examined together with the dialogue recorded during problem solving. Misconceptions were identified using indicators drawn. Each misconception was entered into a table that recorded its type, a representative student answer, and the presumed root cause (Table 1). This table was used to organize the evidence so that every claim about a misconception could be traced to a concrete student answer.

Each identified error was then assigned to one of three processes. Formulating refers to translating the situation into a mathematical representation, employing refers to using the appropriate concept, formula, or operation, and interpreting refers to making sense of and justifying the result. The proportion of errors in each process was calculated relative to all identified errors. Responses to the second test were compared with the patterns found in the first test to determine whether the same misconceptions remained evident.

RESULTS

This section reports the findings in the order in which the data were collected. It begins with the outcome of the first test, because that outcome guided the design of the second test. It then presents the two problems with the dialogue that accompanied them, the misconceptions identified, their distribution across the three literacy processes, and the outcome of the second test. Each table and figure is introduced with a statement of what it shows and why it is included.

Outcome of the first test

In the first test, 3 of the 15 students answered the problems correctly and coherently. Several other students showed a similar tendency: they understood the problem procedurally but made errors in translating the context and in applying basic mathematical concepts. The first test therefore indicated that conceptual and procedural misconceptions were the main obstacles for this group. This result is reported first because it forms the baseline against which the second test is read, and because it guided the design of the second test.

Problem 1: plane figures

The first problem is reported in this subsection because it provides the evidence on the formulating process and on the geometry-related misconceptions. Figure 1 presents the problem so that readers can see the everyday scenario and the shape that students were asked to work with. The figure is included because the interpretation of the students' answers depends on the exact task they received. The problem aimed to determine the extent of students' ability to solve contextual problems on plane figures.

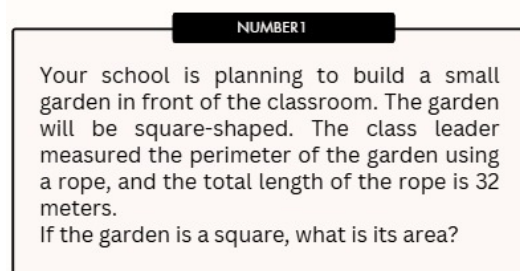


Figure 1. Geometry problem

Figure 1 allows readers to judge whether the task actually targets the confusion between a square and a rectangle. The task was designed to elicit this confusion, which is one of the misconceptions frequently reported among students. Readers can also check

that the problem is framed in an everyday context and does not rely on technical language. This information supports the later reading of Table 1, in which several misconceptions refer to the steps needed to solve this problem.

During problem solving, the researchers engaged in dialogue with the students. The dialogue is reported because written answers show what students produced, whereas the dialogue shows the reasoning behind those answers. The researchers asked questions such as the following (translated from Indonesian):

“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?”

Most students gave one of three responses to these questions. First, they described a square as a shape with four sides, without regard to whether the sides are equal in length or the angles are equal in size. Second, they were confused and unable to give an example of a square in the classroom. Third, they stated that the whiteboard is a square because it has four sides. These three responses show that students used the number of sides as the main criterion for naming a square, and they provide the basis for the formulating errors reported in Section 3.6.

Problem 2: fractions

The second problem is reported because it provides the evidence on the fraction-related misconceptions and on the interpretation of keywords. Figure 2 presents the problem designed by the researchers for the fraction topic. The figure is included so that readers can see how the keyword “of” (*dari*) appears in the problem and can judge whether the operation needed is signaled clearly. The topic was chosen because number material is among the topics with a high rate of misconceptions at the elementary level.

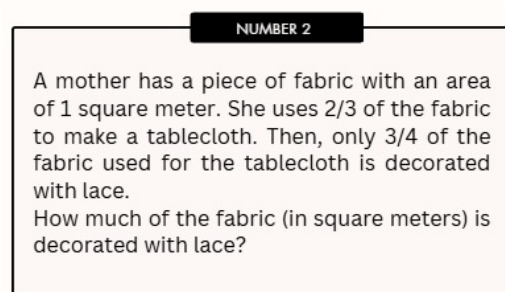


Figure 2. Fraction problem

Figure 2 helps readers connect the later findings with the wording of the task. Many students are able to solve simple arithmetic operations such as $2 + 2 = 4$, but they tend to have difficulty when the same kind of operation is embedded in a contextual problem. The problem in Figure 2 represents this situation, because the operation is expressed through everyday language and not through a symbolic expression. For this reason, the figure is needed to interpret the operation-related errors listed in Table 1.

The dialogue between the researchers and the students reinforced these findings and was consistent with the written answers on the answer sheets. The agreement between the two data sources increases confidence that the classification of errors reflects what students actually thought. 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 observation is the basis for the keyword-related misconception reported in Table 1.

Types of misconceptions

Table 1 summarizes the misconceptions identified in the students' answers. The table is included because it links each misconception to a concrete student answer and to a presumed root cause, which allows readers to verify the classification. The misconception indicators were drawn from established frameworks, and the dialogue was used to support the presumed causes. Eight types were identified across the two problems.

Table 1. Misconceptions identified in students' answers

No	Type of misconception	Student's answer	Presumed root cause
1	Incorrect concept of shape	Student drew a rectangle instead of a square	(a) Did not recognize that a square, by definition, has all sides equal in length; (b) was accustomed to drawing rectangles in everyday life
2	Applying the wrong formula	Student found the correct side length but computed the area with the perimeter formula ($A = 4 \times \text{side}$)	(a) Confused perimeter and area; (b) assumed every square formula uses $4 \times \text{side}$
3	Direct calculation using perimeter	Student multiplied the perimeter directly without first finding the side length	Did not recognize the relationship among perimeter, side length, and area
4	Summing perimeter lengths	Student added the perimeter figures in an attempt to find the area	Did not understand that area refers to a surface (region) and perimeter to a length

5	Choosing the wrong operation	Student used subtraction in a step that required multiplication	Did not interpret the keyword “of” (<i>dari</i>) as indicating multiplication
6	Equalizing denominators before multiplying fractions	Student equalized the denominators before multiplying the fractions	Assumed that every fraction operation requires common denominators
7	Cross-multiplying and then adding	Student applied a cross-multiplication pattern and then added the results	(a) Misapplied the cross-multiplication procedure; (b) did not understand the structure of fractions
8	Inventing a personal rule	Student cross-multiplied the fractions and wrote the result as a single combined number (tens and units)	Did not understand the operation, which led to a self-invented rule

Table 1 should be read from left to right, beginning with the type of misconception and ending with its presumed root cause. Types 1 to 4 arose in the plane figure problem and concern the concept of a square and the relationship among perimeter, side length, and area. Types 5 to 8 arose in the fraction problem and concern the keyword “of” and the procedures students applied to fractions. The presumed causes are interpretations supported by the dialogue, and they are discussed in relation to previous studies in Section 4.

Distribution of errors across the literacy processes

Figure 3 shows where in the solution process the errors occurred. The figure is included because it answers the second aim of the study, namely how misconceptions are distributed across the formulating, employing, and interpreting processes. It also allows readers to see which process accounts for the largest share of errors. The proportions are calculated relative to all identified errors.

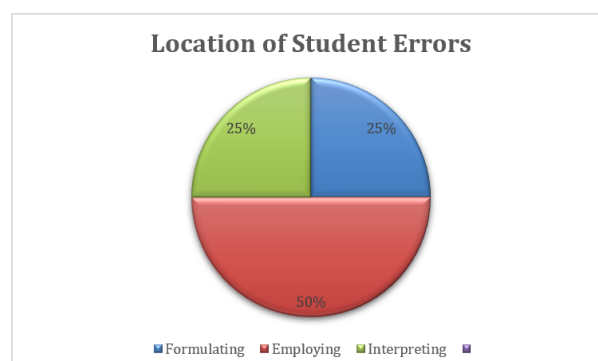


Figure 3. Distribution of student errors across processes

Figure 3 indicates that half of the identified errors occurred in the employing process, and one quarter each occurred in the formulating and interpreting processes. These proportions describe this group of 15 students and should be read as descriptive. They show that difficulties were present at every stage of the solution process, with the heaviest concentration in the use of concepts, formulas, and operations. The following paragraphs describe each process in turn so that the proportions can be connected with concrete student behavior.

The largest share of errors, 50% of all identified errors, occurred in the employing process. Examples include computing area with the perimeter formula (Type 2), multiplying the perimeter directly (Type 3), being unable to determine the side length, and using the wrong arithmetic operation for fractions (Types 5 and 6). Students frequently used the perimeter formula without examining what the problem asked for. These errors indicate that students still experience obstacles with the basic concepts that underlie mathematical literacy problems.

Errors in the formulating process accounted for 25% of the identified errors. These students tended to draw a square as a rectangle because they regarded any plane figure with four sides as a square (Type 1). In several cases, the researchers prompted students with questions about the properties of plane figures to check whether the error was a slip. Despite this prompting, some students remained convinced that a rectangle and a square are the same shape. This persistence suggests that the error reflects a stable idea about shape and not a momentary lapse.

Errors in the interpreting process also accounted for 25%. These students understood the intent of the problem and identified an appropriate formula, but difficulties arose when they computed and wrote the result. When the researchers asked clarifying questions about the origin of the results, the students defended their answers and explained that their calculation method was correct. This behavior indicates that the difficulty involved the reinterpretation of results as well as procedure. Conceptual and formulaic understanding alone did not enable these students to interpret their results correctly.

Outcome of the second test

The outcome of the second test is reported because it addresses the third aim of the study, which concerns whether the misconceptions remained evident after approximately one

month. In the second test, roughly half of the students answered correctly. The remaining students still showed misconceptions consistent with those identified in the first test. The proportion is reported as approximate, and it describes this class on this occasion without implying a change caused by instruction.

DISCUSSION

Formula use in the employing process

The most frequent errors occurred in the employing process, where students used the perimeter formula to find area, multiplied or added perimeter figures, or could not determine the side length. A plausible explanation is that students retrieved a familiar formula for squares without linking it to the quantity the problem asked for. The probing responses, in which students assumed that every square formula uses $4 \times \text{side}$, are consistent with this reading. The finding is meaningful because half of all identified errors fell in this process, which makes it the main target for instructional attention in this group. Previous studies have reported similar confusion. Tan Şişman and Aksu (2016) found that sixth-grade students confused the area formula with the perimeter formula, alongside other misconceptions in spatial measurement. The agreement between that study and the present one suggests that this confusion appears across different primary school settings. The persistence of well-practiced patterns offers an additional perspective. In a study of equation solving, McNeil and Alibali (2005) reported that knowledge of operational patterns hindered learning and performance on equations, although that study concerned mathematical equivalence, so the parallel with area and perimeter is an analogy that should be treated cautiously.

Different patterns have been reported in studies of context-based tasks. Wijaya et al. (2014) found that errors concentrated in understanding the context (38%) and in transforming the task into a mathematical problem (42%), whereas the largest share in the present study fell in the employing process (50%). This variation may be associated with differences in task design, because the tasks here were built around misconceptions anticipated in advance. It may also be associated with differences in participants' grade level, in content domains, and in the classification schemes used to assign errors. The two sets of percentages should therefore be compared with caution.

The findings may be interpreted in relation to the iterative development of conceptual understanding and procedural skill described by Rittle-Johnson et al. (2001). In this view, limited conceptual understanding of area as a surface could restrict students' ability to select and apply an appropriate procedure, even when a formula is available. An instructional implication is that tasks asking students to explain what a formula computes, and to compare area and perimeter within the same context, may be worth trialing. This implication remains tentative, because the present study did not test such tasks.

Classification of plane figures in the formulating process

In the formulating process, students regarded any four-sided figure as a square, drew a rectangle when a square was required, and judged the whiteboard to be a square because it has four sides. Students' statement that a square and a rectangle are the same because both have four sides is partly defensible, since a square can be classified as a special case of a rectangle. The difficulty arises when a single property is treated as sufficient. If four sides alone defined a square, parallelograms, rhombuses, and trapezoids could also be classified as squares, and equal side length needs to be combined with four right angles to define a square.

Previous research by Fujita (2012) indicates that learners often rely on prototypical figures and find inclusion relations among quadrilaterals difficult. The present responses are consistent with this pattern, and the presumed cause of habitual drawing of rectangles in Table 1 points in the same direction. This interpretation should be held with care, because the present study did not assess the full hierarchy of quadrilaterals. The learners in Fujita's study also differ from the participants here in context, so the comparison indicates a similar tendency and does not establish equivalence.

The view of Smith et al. (1994), that prior conceptions can be both flawed and productive, is relevant to this finding. The idea of "four sides" is a valid but incomplete property, which means that it can serve as a starting point for refinement. Classroom activities that use examples and non-examples and that connect equal side length with right angles may help students refine this idea. Such activities would also address the finding that some students stayed convinced of their view after the researchers' prompting, because they give students evidence that a single property is insufficient.

Fractions and keywords

In the fraction problem, students equalized denominators before multiplying, cross-multiplied and added, combined results into a single number, or used subtraction where the keyword “of” signals multiplication. A plausible explanation is that students generalized procedures from addition and subtraction to multiplication. When concepts were unclear, they appear to have created personal rules. The dialogue supports this explanation, because students tended to skim the problem and did not examine the keywords that determine the direction of the solution.

Studies on fractions provide a basis for this interpretation. In a review of the origins and implications of whole number bias, Ni and Zhou (2005) discussed how properties of whole numbers are applied to fractions. This bias may be relevant to the combined-number answers in Type 8, although the present data cannot confirm it. Siegler and Pyke (2013) reported that fraction magnitude knowledge and whole number division predicted fraction arithmetic, which suggests that procedural errors may be linked to conceptual understanding. In addition, Braithwaite et al. (2019) noted that difficulties with fractions often persist after years of instruction, and this observation fits the persistence of these errors among Grade 5 students.

Regarding the keyword “of”, Hegarty et al. (1995) reported that unsuccessful solvers tend to rely on direct translation of numbers and keywords, whereas successful solvers build a model of the situation. In the present data, the difficulty was that students did not interpret “of” as a relation requiring multiplication. These two patterns can coexist, because attention to isolated words does not guarantee a representation of the quantitative relations those words signal. Vilenius-Tuohimaa et al. (2008) reported a close relationship between reading comprehension and word-problem performance, but reading comprehension was not measured in this study, so the connection remains tentative.

An instructional implication follows from these observations. Teachers could ask students to restate the unknown quantity in their own words and to represent the situation before choosing an operation. This practice would direct attention to the relation expressed by a keyword before a procedure is selected. It would also make students’ reasoning visible, which gives teachers an opportunity to detect rules that students have invented. The usefulness of this practice should be evaluated in future classroom studies.

Interpreting results and the stability of misconceptions

In the interpreting process, students who understood the problem and chose an appropriate formula still defended answers that were incorrect. This behavior can be read in light of Smith et al. (1994), who described students' conceptions as knowledge that may be coherent from the student's own perspective. Limited monitoring and evaluation of one's own thinking may also contribute to the behavior. Veenman et al. (2006) discussed conceptual and methodological considerations in research on metacognition and learning, and this literature offers a framework for such an explanation. Because metacognition was not measured here, the explanation is offered as a hypothesis for later study.

In the second test, about half of the students still showed misconceptions consistent with the first test. This pattern can be read in relation to the conceptual change approach, which examines how students' existing knowledge shapes new learning in mathematics (Vosniadou & Verschaffel, 2004). The pattern suggests that early misconceptions may remain available to students and may influence how they approach later problems. The interpretation requires caution, because the second test used similar but not identical problems and the interval was approximately one month. In addition, the instruction that occurred between the tests was not documented, so the present design describes persistence in this class and does not allow conclusions about the effect of instruction.

Implications for instruction

The findings point to a learning sequence that begins with reading the problem, identifying important information, understanding what is asked, and only then selecting a method. Such a sequence addresses the points at which errors were observed, namely shape properties, formula meaning, keyword interpretation, and checking of results. The sequence also corresponds to the three processes used in this study, because it places the understanding of context before the use of formulas. These implications are drawn from a small descriptive study and should be treated as suggestions for further testing.

Problem-Based Learning (PBL) is one approach that could accommodate this sequence. According to Hmelo-Silver (2004), PBL is designed to help students develop flexible knowledge, problem-solving skills, self-directed learning, collaboration skills, and intrinsic motivation. A meta-analysis by Dochy et al. (2003) reported positive effects of PBL on students' skills and mixed evidence for knowledge acquisition. This evidence

suggests that PBL would need to be combined with explicit attention to the concepts identified in this study, such as the properties of squares, the meaning of area, and the structure of fraction multiplication.

The implementation of such approaches depends on teacher support. Wijaya et al. (2024) reported that teachers recommended more training and improved learning resources to enhance students' mathematics achievement. This recommendation indicates that teachers may need professional development in diagnosing misconceptions and in guiding students through structured problem solving. The effectiveness of a structured sequence combined with PBL has not been tested in this study. It remains a question for future research with designs that can examine change in students' understanding.

Limitations and future research

Several limitations should be noted. The study involved 15 students from one class, so the findings describe this context and cannot be generalized. The percentages of errors across processes depend on the number of errors identified and should be read as descriptive. The two tests used different problems, which limits direct comparison between them. Probing questions may also have influenced students' responses, a possibility discussed by Fox et al. (2011).

These limitations suggest several directions for future work. Studies with larger samples from several classrooms would show whether the distribution of errors across the three processes is similar in other settings. Documenting the instruction delivered between tests would allow researchers to examine how teaching relates to the persistence of misconceptions. Reading comprehension and mathematics anxiety could be examined in relation to the interpretation of results. Finally, interventions designed to remediate the misconceptions identified here could be evaluated with designs that compare students before and after instruction.

CONCLUSION

This study examined the misconceptions of 15 Grade 5 students in solving mathematical literacy problems on plane figures and fractions. Eight types of misconceptions were identified across the two problems. Half of the identified errors occurred in the employing process, and one quarter each occurred in the formulating and interpreting processes. In

the second test, about half of the students answered correctly, and the remaining students showed misconceptions consistent with those found in the first test.

The findings suggest that instruction on mathematical literacy problems may benefit from explicit attention to the properties of shapes, the meaning of formulas, the interpretation of keywords, and the checking of results. A structured, context-first sequence combined with Problem-Based Learning is a plausible direction for classroom practice. Its effectiveness needs to be tested in further research with larger and more varied samples. Such research would also clarify whether the distribution of errors reported here holds in other classrooms and content areas.

REFERENCES

- Blum, W., & Niss, M. (1991). Applied mathematical problem solving, modelling, applications, and links to other subjects: State, trends and issues in mathematics instruction. *Educational Studies in Mathematics*, 22(1), 37–68. <https://doi.org/10.1007/BF00302716>
- Braithwaite, D. W., Leib, E. R., Siegler, R. S., & McMullen, J. (2019). Individual differences in fraction arithmetic learning. *Cognitive Psychology*, 112, 81–98. <https://doi.org/10.1016/j.cogpsych.2019.04.002>
- Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: A meta-analysis. *Learning and Instruction*, 13(5), 533–568. [https://doi.org/10.1016/S0959-4752\(02\)00025-7](https://doi.org/10.1016/S0959-4752(02)00025-7)
- Fox, M. C., Ericsson, K. A., & Best, R. (2011). Do procedures for verbal reporting of thinking have to be reactive? A meta-analysis and recommendations for best reporting methods. *Psychological Bulletin*, 137(2), 316–344. <https://doi.org/10.1037/a0021663>
- Fujita, T. (2012). Learners' level of understanding of the inclusion relations of quadrilaterals and prototype phenomenon. *The Journal of Mathematical Behavior*, 31(1), 60–72. <https://doi.org/10.1016/j.jmathb.2011.08.003>
- Hegarty, M., Mayer, R. E., & Monk, C. A. (1995). Comprehension of arithmetic word problems: A comparison of successful and unsuccessful problem solvers. *Journal of Educational Psychology*, 87(1), 18–32. <https://doi.org/10.1037/0022-0663.87.1.18>
- Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, 16(3), 235–266. <https://doi.org/10.1023/B:EDPR.0000034022.16470.f3>
- McNeil, N. M., & Alibali, M. W. (2005). Why won't you change your mind? Knowledge of operational patterns hinders learning and performance on equations. *Child Development*, 76(4), 883–899. <https://doi.org/10.1111/j.1467-8624.2005.00884.x>
- Ni, Y., & Zhou, Y.-D. (2005). Teaching and learning fraction and rational numbers: The origins and implications of whole number bias. *Educational Psychologist*, 40(1), 27–52. https://doi.org/10.1207/s15326985ep4001_3
- Rittle-Johnson, B., Siegler, R. S., & Alibali, M. W. (2001). Developing conceptual understanding and procedural skill in mathematics: An iterative process. *Journal of Educational Psychology*, 93(2), 346–362. <https://doi.org/10.1037/0022-0663.93.2.346>

- Sandelowski, M. (2000). Whatever happened to qualitative description? *Research in Nursing & Health*, 23(4), 334–340. [https://doi.org/10.1002/1098-240X\(200008\)23:4<334::AID-NUR9>3.0.CO;2-G](https://doi.org/10.1002/1098-240X(200008)23:4<334::AID-NUR9>3.0.CO;2-G)
- Siegler, R. S., & Pyke, A. A. (2013). Developmental and individual differences in understanding of fractions. *Developmental Psychology*, 49(10), 1994–2004. <https://doi.org/10.1037/a0031200>
- Smith, J. P., III, diSessa, A. A., & Roschelle, J. (1994). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The Journal of the Learning Sciences*, 3(2), 115–163. https://doi.org/10.1207/s15327809jls0302_1
- Stacey, K. (2011). The PISA view of mathematical literacy in Indonesia. *Journal on Mathematics Education*, 2(2), 95–126. <https://doi.org/10.22342/jme.2.2.746.95-126>
- Tan Şişman, G., & Aksu, M. (2016). A study on sixth grade students' misconceptions and errors in spatial measurement: Length, area, and volume. *International Journal of Science and Mathematics Education*, 14(7), 1293–1319. <https://doi.org/10.1007/s10763-015-9642-5>
- Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning*, 1(1), 3–14. <https://doi.org/10.1007/s11409-006-6893-0>
- Verschaffel, L., Schukajlow, S., Star, J., & Van Dooren, W. (2020). Word problems in mathematics education: A survey. *ZDM Mathematics Education*, 52(1), 1–16. <https://doi.org/10.1007/s11858-020-01130-4>
- Vilenius-Tuohimaa, P. M., Aunola, K., & Nurmi, J.-E. (2008). The association between mathematical word problems and reading comprehension. *Educational Psychology*, 28(4), 409–426. <https://doi.org/10.1080/01443410701708228>
- Vosniadou, S., & Verschaffel, L. (2004). Extending the conceptual change approach to mathematics learning and teaching. *Learning and Instruction*, 14(5), 445–451. <https://doi.org/10.1016/j.learninstruc.2004.06.014>
- Wijaya, A., van den Heuvel-Panhuizen, M., Doorman, M., & Robitzsch, A. (2014). Difficulties in solving context-based PISA mathematics tasks: An analysis of students' errors. *The Mathematics Enthusiast*, 11(3), 555–584. <https://doi.org/10.54870/1551-3440.1317>
- Wijaya, T. T., Hidayat, W., Hermita, N., Alim, J. A., & Talib, C. A. (2024). Exploring contributing factors to PISA 2022 mathematics achievement: Insights from Indonesian teachers. *Infinity Journal*, 13(1), 139–156. <https://doi.org/10.22460/infinity.v13i1.p139-156>