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Primary Students' Errors in Solving Mathematical Literacy Problems Based on Newman Analysis

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Abstract

Successfully solving mathematical literacy problems by primary students is essential to prepare an earlier generation to deal with various problems in life contexts and have a positive motivation towards mathematics. Previous empirical evidence shows that primary students are still solving mathematical literacy problems with various incorrect strategies and various levels of errors. Meanwhile, Newman Errors Analysis (NEA) can be used to analyze the forms of primary students' errors in solving problems. This research aims to analyze the forms of primary students' errors in solving mathematical literacy problems using NEA. This research applied a qualitative method, with subjects consisting of 35 fifth-grade primary students. Data was collected using tests, interviews, and documentation. Data analysis techniques regarding primary students' errors were carried out through three stages: data reduction, data presentation, and conclusion drawing. The forms of errors are emphasized in NEA categories, namely reading, comprehension, transformation, process skills, and encoding. The results showed that primary students made all forms of Newman errors in solving mathematical literacy problems. The highest form of error is comprehension errors, while the lowest is process skill. The research results suggest that primary students need to be familiar with numeracy learning, emphasizing meaningful comprehension to avoid errors in solving mathematical literacy problems.

Keywords: NEA, Mathematical Literacy Problems, Flat Shapes, Student Errors, Primary School

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INTRODUCTION

Solving mathematical literacy problems is vital to support the success of mathematics proficiency rankings in various countries (Runtu et al., 2023). This is because mathematical literacy problems is needed to build skills or expertise in the 21st century (Ulger et al., 2022). In addition, mathematical literacy problems are also considered necessary to be presented in the Education curriculum (Canbazoğlu & Tarim, 2021). Mathematical literacy problems are also significant in daily life to emphasize one's mathematical ability, which depends on one's level of knowledge and skills (Genc & Erbas, 2020). Emphasizing and practicing mathematical literacy problems can also improve one's mathematical literacy skills (Fery et al., 2017).

Solving mathematical literacy problems is essential for primary students because they can build their ability to formulate, apply, and interpret mathematics in various contexts (Susanta et al., 2023). In addition, mathematical literacy problem-solving ability for primary students can be seen as essential to produce a generation that is ready to face various problems in life (Stevenson et al., 2014), enhance their ability in complex thinking skills (Kolar & Hodnik, 2021), and also skills and competencies in general (Rizki & Priatna, 2019). The emphasis can be increased through primary students' habit of solving mathematical literacy problems (Lestariningsih et al., 2020). Meanwhile, mathematical literacy

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problems are good enough to train real-world problem-solving skills (Pratama et al., 2018).

Primary students have deficiencies in understanding problems in mathematical literacy, as evidenced by primary students' difficulties in determining problem-solving strategies (Fery et al., 2017; Juanti et al., 2021; Malihatuddarojah et al., 2019). This opinion is in line with that expressed by Schukajlow et al. (2022), who stated that solving mathematical literacy problems is one of the essential things in fostering learning motivation. Also, problems arise regarding the mathematical literacy problems of primary students due to many factors, including the habit of primary students in solving problems and the level of very diverse errors (Nuryati et al., 2022). Therefore, a method is needed to analyze the forms of errors made by primary students in solving mathematical literacy problems.

The Newman Errors Analysis (NEA) method can analyze the forms of primary students' errors in solving problems (Haerani et al., 2021). NEA is a method used to analyze errors related to the problem in detail (Darmawan et al., 2018). NEA has five stages: reading, comprehension, transformation, process skills, and encoding (Lestari et al., 2018). Based on those stages, primary students' errors can be described as follows: 1) Reading errors are student errors in interpreting problem sentences; 2) Comprehension errors are students unable to use words or terms in solving problems; 3) Transformation errors are students unable to analyze problem instructions; 4) Process skills errors are students unable to use problem-solving procedures; and 5) Encoding errors are students incorrectly writing words or terms in solving problems.

Previous studies showed that some primary students can solve problems while others often make mistakes in solving mathematical literacy problems (Ratnaningsih et al., 2022; Wardhani & Argaswari, 2022). Research by Nuryati et al. (2022) shows primary students make errors when solving problems. These errors occur because primary students cannot understand the problem (Abdullah et al., 2015). However, these studies have not thoroughly analyzed the form of errors made by primary students in solving mathematical literacy problems.

Meanwhile, previous studies that used the NEA method to analyze primary students' errors in solving problems still have not researched primary students' errors in solving mathematical literacy problems based on NEA. This study shows the importance of analyzing the forms of primary students' errors in solving problems based on NEA. Thus, this study aims to analyze the forms of primary students' errors in solving mathematical literacy problems based on Newman's analysis.

METHODS

Research Approach

The research used a qualitative approach to analyze the forms of primary students' errors in solving mathematical literacy problems based on Newman's analysis. The several stages of research carried out are determining the research focus and the research subject, collecting and processing the data, analyzing data based on NEA indicators, and finally, presenting data from the analysis results.

Research Subject

The research subjects were 35 fifth-grade students at Pucang 2 Sidoarjo State Primary School. Subjects were given a mathematical literacy test with flat building material. In this process, the determination of subjects using purposive sampling in qualitative research is a sampling technique with certain criteria (Miles et al., 2014). Then, the test results were analyzed and categorized based on NEA errors.

Data Collection

The data collection includes tests, interviews, and documentation. The test was used to get written data about the forms of students' errors in solving mathematical literacy problems. The interview was used to deepen the forms of errors and explore the causes of students' errors in solving mathematical literacy problems. Documentation is done through video recording to get other data that can support the justification of the forms and causes of errors during the interview, for example, gestures or thought processes when confirming written test answers. After obtaining data stating primary students' errors in solving mathematical literacy problems, some students were selected for interviews with certain criteria. The criteria set for the students interviewed were students who made the most errors in solving mathematical literacy problems based on NEA.

Data Analysis

Data analysis uses several stages of data reduction, data presentation, and conclusion (Miles et al., 2014). First, data reduction is used to analyze the results of written tests and interviews. In this, every primary student who makes errors in solving problems will be given an error code according to their type of NEA error. NEA has five stages: reading, comprehension, transformation, process skill, and encoding. The NEA indicators and code errors are presented in Table 1. It is developed based on indicators by White (2009). The mention of primary students uses code S1 to state primary students with attendance number 1, and so on until the last attendance. Second, data presentation in clear descriptions and tables makes it easier for researchers to understand research data. Third, the conclusion is the form of new research findings that have never existed in previous research findings.

Table 1. Errors indicators based on NEA

NEA Component	Errors Indicators	Code Errors
Reading	Students cannot interpret the meaning of words or terms contained in the problem sentence	R1
	Students are unable to interpret the meaning of symbols in problems	R2
Comprehension	Students are unable to use words or terms appropriately in solving problems	C1
	Students are unable to use symbols appropriately in solving problems	C2
Transformation	Students do not realize the benefits of the problem clues	T1
	Students are unable to draw the units of square and surface area according to the context of the problem	T2
Process skill	Students cannot use the solution procedure correctly	P1
	Students cannot connect the picture with the formula	P2
Encoding	Students make mistakes in writing words or terms contained in the problem sentence	E1
	Students make mistakes in writing mathematical symbols in problems	E2

Research Instrument

The research instruments included a mathematical literacy problem test and interview guidelines. The test was used to classify the errors made by primary students when solving problems. The mathematical literacy problems test instrument was developed based on Wickstrom et al. (2017) in Table 2. In comparison, the interview is a series of oral questions that aim to deepen the causes of primary students' errors in solving mathematical literacy problems. The validity of this research data is checked using triangulation by comparing test results with interview results and picture evidence to produce the causes of primary students' errors.

Table 2. Research instruments

Mathematical Literacy Problem Test
Instructions • Complete the mathematical literacy test provided! • The tiles must have no gaps and must not overlap. Problem Helsa has a rectangular bedroom with a size of $1\ m \times 2\ m$. Helsa wants to replace her bedroom tiles with a size of $40\ cm$ square. Help Helsa sketch her bedroom and tiles so she can determine how many tiles can cover the entire floor surface of her bedroom (you can cut or use some tiles)!

RESULTS AND DISCUSSION

Based on NEA procedures, primary students can make errors in solving mathematical literacy problems grouped into five forms, namely: (1) reading errors, (2) comprehension errors, (3) transformation errors, (4) process skills errors, and (5) encoding errors. Each form of error is divided into several indicators, namely: (1) Reading errors, students cannot interpret the meaning of words or terms contained in the problem sentence (Code R1); students cannot interpret the meaning of symbols in the problem (Code R2); (2) Comprehension errors, students cannot use words or terms appropriately in solving problems (Code C1); students cannot use symbols appropriately in solving problems (Code C2); (3) Transformation errors, students do not realize the benefits of problem instructions (Code T1); (Code T2); (4) Process skills errors, students cannot use the solution procedure appropriately (Code P1); students cannot connect the picture with the formula (Code P2); and (5) Encoding errors, students make errors in writing words or terms contained in the problem sentence (Code E1); students make errors in writing mathematical symbols in the problem (Code E2).

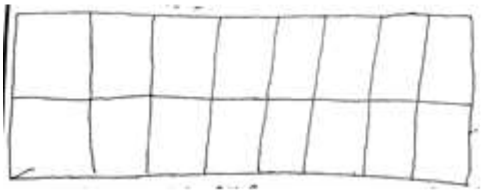
Table 3 shows primary students' errors in solving mathematical literacy problems. Each NEA code error shows that 24 students made errors (68,57%) with code R1, 3 students (8,57%) with code R2, 10 students (28,57%) with code C1, 32 students (91,43%) with code errors C2, 4 students (11,43%) with code errors T1, 29 students (82,86%) with code errors T2, 5 students (14,29%) with code errors P1, 1 student (2,86%) with code errors P2, 12 students (34,29%) with code errors E1, and 27 students (77,14%) with code errors E2. All forms of errors came up for primary students: reading, comprehension, transformation, process skills, and encoding. The highest error is C2, which cannot use symbols appropriately in solving problems. Meanwhile, the lowest error is P2, which cannot connect the picture with the formula.

Table 3. Recapitulation of student errors

Student Errors		N	%
Reading (R)	R1	24	68,57
	R2	3	8,57
Comprehension (C)	C1	10	28,57
	C2	32	91,43
Transformation (T)	T1	4	11,43
	T2	29	82,86
Process skill (P)	P1	5	14,29
	P2	1	2,86
Encoding (E)	E1	12	34,29
	E2	27	77,14

Students' Reading Errors

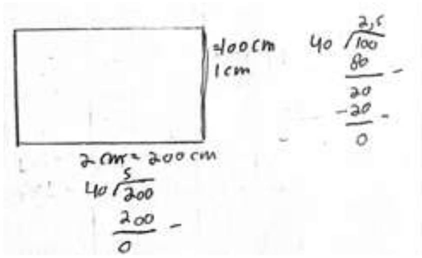
The errors experienced by primary students in solving mathematical literacy problems were analyzed based on the first NEA indicator, namely reading errors. A total of 24 primary students (68,57%) made reading errors on indicator R1. Reading errors in solving mathematical literacy problems are primary students' inability to interpret the sentence "may cut and use some tiles." Reading errors occur when primary students cannot interpret the problem sentence. The first indicator's final result of reading errors is primary students' sketches showing a bedroom with whole tiles, as shown in Figure 1.



The student could not analyze the problem sentence "can cut and use some of the tiles." Therefore, the student made mistakes when drawing the sketch.

Figure 1. Reading errors indicator R1

The subsequent reading errors in indicator R2 were experienced by three primary students (8.57%). Reading errors in indicator R2 in solving mathematical literacy problems are primary students are wrong in interpreting the size of a $1m \times 2m$ bedroom and the size of a $40\ cm$ square tile. Primary students can determine formulas and arithmetic operations but incorrectly interpret the symbol $1\ m$ into $1\ cm$ or $100\ cm$ and $2\ m$ into $2\ cm$ or $200\ cm$, as shown in Figure 2.

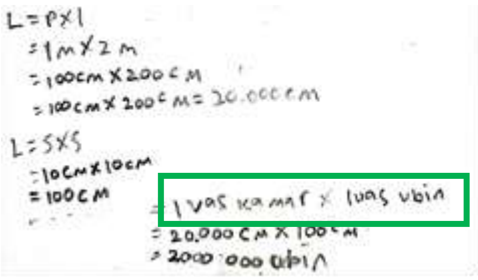


Students can determine formulas and calculation operations but make mistakes in interpreting symbols so that students cannot continue their work.

Figure 2. Reading errors indicator R2

Students' Comprehension Errors

The errors experienced by primary students in solving mathematical literacy problems based on the second NEA are errors in understanding. Ten primary students (28,57%) experienced comprehension errors in indicator C1. Comprehension errors in solving mathematical literacy problems include primary students not being able to interpret the words or terms "many tiles that can cover the entire surface of the bedroom floor." In contrast, primary students perform arithmetic operations of the bedroom area $20.000\ cm$ $(100\ cm\ \times 200\ cm) \times 100\ cm$ tile area $(10\ cm\ \times 10\ cm)$ to determine many tiles, as shown in Figure 3.

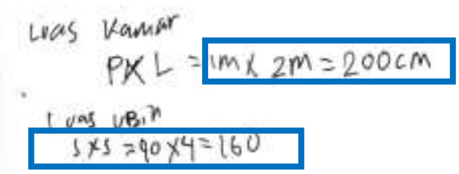


Translated into English:

$L = p \times l$
$= 1\ m\ \times 2\ m$
$= 100\ cm\ \times 200\ cm$
$= 100\ cm\ \times 200\ cm\ = 20.000\ cm$
$L = s \times s$
$= 10\ cm\ \times 10\ cm$
$= 100\ cm$
$=$ spacious bedroom × tile area
$= 20.000\ cm\ \times 100\ cm$
$=$ 2000000 Tiles

Figure 3. Comprehension errors indicator C1

The subsequent comprehension errors on indicator C2 were experienced by 32 primary students (91,43%). The comprehension errors were that primary students made mistakes in converting the meter unit into a centimeter $1\ m \times 2\ m = 200\ cm$, and primary students made mistakes in interpreting $40\ cm$ square into $40\ cm \times 4 = 160$, as shown in Figure 4.



Translated into English:

Spacious bedroom

$p \times l = \boxed{1\ m \times 2\ m = 200\ cm}$

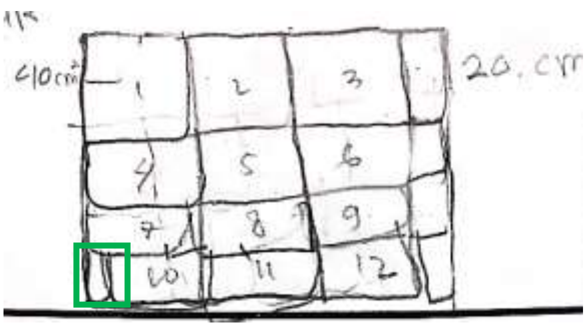
Tile area

$\boxed{s \times s = 40 \times 4 = 160}$

Figure 4. Comprehension errors indicator C2

Students' Transformation Errors

The errors experienced by primary students in solving mathematical literacy problems based on the third NEA are errors in transformation. Four students (11,43%) experienced transformation errors in indicator T1. Transformation errors in solving mathematical literacy problems are shown when they cannot understand the problem instructions: "tiles arranged should not have gaps and should not overlap," so they sketch a bedroom with tiles overlapping and having gaps—one example of transformation errors in indicator T1 in Figure 5.

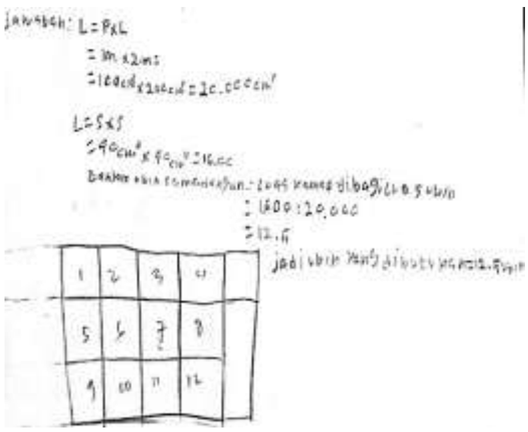


Translated into English:

Students did not realize the benefit of the problem instruction: "The tiles should not have gaps and should not overlap". Hence, the sketch drawing presented by the students had overlapping tiles.

Figure 5. Transformation errors indicator T1

The subsequent transformation errors in indicator T2 were experienced by 29 primary students (82,86%). The transformation errors were primary students using the formula first ($20.000\ cm^2 \div 1{,}600\ cm^2 = 12{,}5$ tiles) rather than sketching the bedroom. Primary students could not correctly sketch the bedroom. An example of this error is shown in Figure 6.



Translated into English:

Answer: $L = p \times l$

$= 1\ m \times 2\ m$

$= 100\ cm^2 \times 200\ cm^2 = 20.000\ cm^2$

$L = s \times s$

$= 40\ cm^2 \times 40\ cm^2 = 1.600\ cm^2$

Lots of tiles = spacious bedroom ÷ tile area

$= 20.000\ cm^2 \div 1.600\ cm^2$

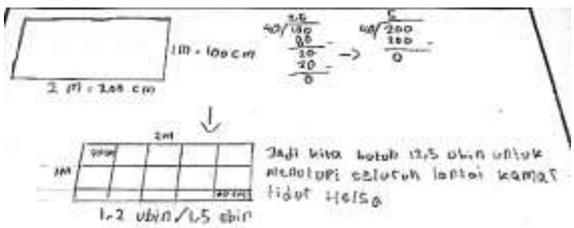
$= 12{,}5$ tiles

So tiles are needed $= 12{,}5$ tiles

Figure 6. Transformation errors indicator T2

Students' Process Skills Errors

The errors experienced by primary students in solving mathematical literacy problems based on the fourth NEA are errors in process skills. Five students (14,29%) who experienced process skills errors were coded in the P1 indicator. Process skills errors in solving mathematical literacy problems are primary students' ability to correctly describe the sketch of the bedroom and tiles. Still, there are errors in the calculation operation. The operation error in primary students changes the room area of $1\ m \times 2\ m$ into centimeters $100\ cm \times 200\ cm$. Also, $100\ cm \div 40\ cm = 2{,}5$ tiles and $200\ cm \div 40\ cm = 5$ tiles. Then $2.5 \times 5 = 12{,}5$ tiles. An example of this error is shown in Figure 7.



Translated into English:

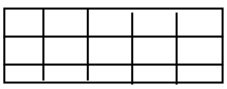
$1\ m = 100\ cm$

$2\ m = 200\ cm$

$$40\overline{)100} = 2{,}5 \quad (80,\ 20,\ 20,\ 0) \qquad 40\overline{)200} = 5 \quad (200,\ 0)$$

$2\ m$ ↓

$1\ m$

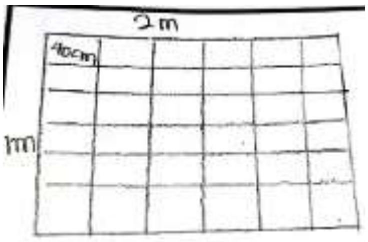


1,2 tiles/1,5 tiles

Thus, need 12,5 tiles to cover the entire Helsa bedroom floor

Figure 7. Process skills errors indicator P1

One student experienced errors in the next process skills in the P2 indicator (2,86%). Process skills errors in solving mathematical literacy problems include primary students' ability to sketch without using a formula because students do not know the formula to determine the number of tiles that can cover the entire surface of the bedroom floor. An example of such errors is shown in Figure 8.

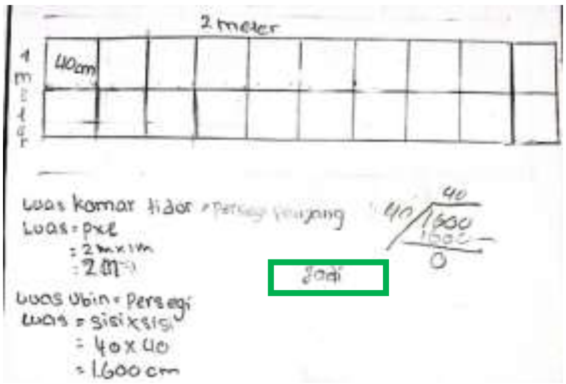


Students do not know the formula to determine the number of tiles that can cover the entire surface of Helsa's bedroom floor. Therefore, students only sketch without using the formula.

Figure 8. Process skills errors indicator P2

Students' Encoding Errors

The errors that primary students experienced in solving mathematical literacy problems based on the fifth NEA are errors in writing answers. There were 12 primary students coded (34,29%) who experienced errors in writing answers on indicator E1. Encoding errors in solving mathematical literacy problems are that primary students cannot continue writing conclusions and make mistakes in answering sentences, which is shown in Figure 9.



Translated into English:

2 meter

40 cm									

Bedroom area = rectangle

$$40 \overline{)1600} = 40, \quad 1600, \quad 0$$

Wide = $p \times l$

$= 2\,m \times 1\,m$

$= 2\,m$ So

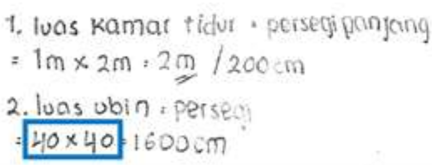
Tile area = square

Wide = side × side

$= 40 \times 40$

Figure 9. Encoding errors indicator E1

A total of 27 primary students (77,14%) experienced encoding errors in writing as an indicator of E2. Primary students did not write the symbol $40\ cm \times 40\ cm$ in the answers. An example of this error is shown in Figure 10.



Translated into English:

1. Bedroom area = rectangle
   $= 1\text{ m} \times 2\text{ m} = 2/\ 200\text{ cm}$
2. Tile area = square
   $= \boxed{40 \times 40} = 1.600\text{ cm}$

Figure 10. Encoding errors indicator E2

The research found that primary students experienced all forms of NEA errors in solving mathematical literacy problems, namely in terms of reading errors, comprehension errors, transformation errors, process skills errors, and encoding errors. This finding is similar to the results of previous research that primary students experience all errors in solving problems based on NEA error analysis but not solving mathematical literacy problems (Agustiani, 2021; Oktafia et al., 2020; Prasetyaningrum et al., 2022; Sukoriyanto, 2020). It was also found that the highest form of error was comprehension in terms of not being able to use symbols appropriately in solving problems. Meanwhile, the lowest error was in terms of process skill, which was not being able to connect the picture with the formula. This shows that students have more difficulty doing symbolic-to-visual representation than symbolic-to-visual representation (Amir et al., 2021; Bütüner, 2020; Pielsticker et al., 2022; Ünal et al., 2023).

The findings regarding the forms and causes of errors in terms of reading errors, comprehension errors, transformation errors, process skills errors, and encoding errors can be further elaborated. It was found that students experienced reading errors when reading problem information; as a result, they drew the wrong sketch. This finding aligns with Prasetyaningrum et al. (2022) that primary students cannot interpret the sentences contained in word problems. Brown and Skow (2016) stated that reading errors are characterized by the failure of primary students to write symbols on the sketch and the inability to identify words or terms in the problem, so they cannot continue their work.

The next error is comprehension errors. Students could not use the meaning of words and symbols in the problem, so they made errors in describing the size of 1 m × 2 m. This finding is similar to that of Lestari et al. (2018), who found that primary students often can read the problem but cannot use words or terms in the problem. In addition, students cannot understand and interpret the use of symbols in solving mathematical literacy problems, so the answers are incorrect (Sari et al., 2023; Wardhani & Argaswari, 2022).

Another finding was transformation errors. Students did not realize the benefit of the problem clues and could not draw square units and surface area according to the context. However, based on the interview results, primary students made these errors because they never drew a sketch. This finding is in line with the findings of Wickstrom et al. (2017) that students fail to make visual representations because they fail to transform problem clues. This can result in errors in visual representations in the form of length and width sketches with certain area units (Abadi & Amir, 2022; Kurniawati & Amir, 2022).

The other finding was process skills errors. It was found that primary students could not use the solution procedure correctly and could not connect the picture with the formula. This finding is similar to previous research that process skills errors are characterized by students not using the correct solution procedure to solve the problem (Oktafia et al., 2020; Prasetyaningrum et al., 2022; Yuliana et al., 2021). This is due to students' inability to apply the strategy to the solution procedure (Oktafia et al., 2020; Sukoriyanto, 2020).

The last finding was encoding errors. Students made errors in writing words or terms in the problem sentence and mathematical symbols. This finding is similar to previous research findings that primary students fail to write words, terms, and symbols (Agustiani, 2021; Astutik & Purwasih, 2023). The cause of this error is a complex factor because it is influenced by previous errors regarding reading errors, comprehension errors, transformation errors, and process skills errors (Astutik & Purwasih, 2023; Oktafia et al., 2020; Prasetyaningrum et al., 2022; Sukoriyanto, 2020; Yuliana et al., 2021).

CONCLUSION

Based on Newman's analysis, it can be concluded that primary students made all forms of errors in solving mathematical literacy: reading, comprehension, transformation, process skills, and encoding. The highest form of errors is comprehension errors, while the lowest is process skills. This is because primary students cannot use words, terms, and symbols in solving problems, so primary students cannot understand and translate problems, cannot use formulas and arithmetic operations, and are not thorough in solving mathematical literacy problems. Based on this, the researcher provides practical advice that primary students need to be familiarized with numeracy learning by emphasizing process, content, and context with meaningful comprehension so that primary students avoid other errors in solving mathematical literacy problems.

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