ANALYSIS OF STUDENTS' ERRORS IN SOLVING LITERACY AND NUMERACY PROBLEMS: A NEWMAN PROCEDURE APPROACH

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Abstract:
Mathematical literacy and mathematical numeracy are basic skills that are crucial for educational progress and individual development. However, students' mathematical literacy and numeracy skills in Indonesia must still meet the expected standards. Therefore, this research aims to analyze students' errors in solving mathematical literacy and mathematical numeracy questions. This research uses qualitative research with a descriptive approach. In this study, six subjects were selected using a purposive sampling technique, with two subjects representing high, medium, and low ability categories. Subject selection criteria are based on the results of essay tests in the algebra domain. Mathematical literacy and mathematical numeracy abilities were analyzed through student error analysis using the Newman error indicator, which includes five procedures: (1) reading, (2) comprehension, (3) transformation, (4) process skills, and (5) encoding. The results showed that students' error rates varied depending on the level of mathematical literacy and numeracy skills. Subjects in the high ability category generally need to improve comprehension, processing skills, and answer writing stages. Subjects in the medium ability category typically make mistakes in the reading, comprehension, processing skills, and answer writing stages. Then, subjects in the low category tend to make mistakes at all stages of analysis. The recommendations from this study are expected to provide valuable insights for educators in designing more effective learning strategies to overcome these errors.

Keywords: Students' Errors, Literacy and Numeracy, Newman Procedure

ANALISIS KESALAHAN PESERTA DIDIK DALAM MEMECAHKAN SOAL LITERASI DAN NUMERASI: PENDEKATAN MELALUI PROSEDUR NEWMAN

Abstrak:
Literasi matematika dan numerasi matematika merupakan keterampilan dasar yang krusial untuk kemajuan pendidikan dan perkembangan individu. Namun, di Indonesia, tingkat kemampuan literasi dan numerasi matematika peserta didik masih belum memenuhi standar yang diharapkan. Penelitian ini bertujuan untuk menganalisis kesalahan siswa dalam menyelesaikan soal literasi matematika dan numerasi matematika. Penelitian ini menggunakan penelitian kualitatif dengan

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pendekatan deskriptif. Enam subjek dipilih menggunakan teknik *purposive sampling*, dua subjek mewakili kategori kemampuan tinggi, sedang, dan rendah. Kriteria pemilihan subjek didasarkan pada hasil tes uraian pada domain aljabar. Kemampuan literasi matematika dan numerasi matematika dianalisis melalui analisis kesalahan siswa menggunakan indikator kesalahan Newman, yang mencakup lima prosedur: (1) membaca, (2) pemahaman, (3) transformasi, (4) keterampilan proses, dan (5) penulisan jawaban. Hasil penelitian menunjukkan bahwa tingkat kesalahan siswa bervariasi, tergantung pada tingkat kemampuan literasi dan numerasi matematika. Subjek dengan kategori kemampuan tinggi umumnya melakukan kesalahan pada tahap pemahaman, keterampilan proses, dan penulisan jawaban. Subjek dengan kategori kemampuan sedang umumnya melakukan kesalahan pada tahap membaca, pemahaman, keterampilan proses, dan penulisan jawaban. Kemudian, subjek dengan kategori rendah cenderung melakukan kesalahan pada semua tahap analisis. Rekomendasi dari penelitian ini diharapkan dapat memberikan wawasan yang berguna bagi para pendidik dalam merancang strategi pembelajaran yang lebih efektif untuk mengatasi kesalahan-kesalahan tersebut.

Kata Kunci: Kesalahan Peserta Didik, Literasi dan Numerasi, Prosedur Newman

INTRODUCTION

Numeracy strengthens students' logical and critical thinking skills and improves their problem-solving skills (Fathani, 2016). In addition, numeracy also supports improving students' ability to solve complex problems (Haryani, 2011). Therefore, numeracy is essential in enhancing students' knowledge and skills to face daily challenges. However, lately, students have been considering numeracy, which could be improved (Siregar & Restati, 2017). This is reinforced by students often making mistakes when solving numeracy problems (Fadilah & Bernard, 2021). Student errors in solving numeracy problems need attention.

Research conducted by Azzahra (2019) revealed several reasons students make mistakes, such as (1) difficulty understanding the meaning of the sentence accurately, (2) difficulty converting the meaning of words into mathematical sentences, and (3) the need to understand the problem. These findings align with the results of Dewi and Kartini (2021) research, which states that most students tend to make mistakes in transformation abilities and

process skills. Students have difficulty transferring information from the problem into a mathematical model, which causes transformation errors. On the other hand, most students also need help with process skills, such as computational errors and calculation omissions. Students need to improve their ability to manipulate mathematical concepts.

In the context of this error finding, literacy and numeracy are becoming increasingly prominent aspects of improving students' numeracy skills. However, research results and surveys from international institutions show that students' literacy and numeracy skills in Indonesia are still not as expected. The low level of literacy and numeracy skills in Indonesia is highlighted by the PISA 2022 report (OECD, 2023). The report shows a decrease in the literacy score of students in Indonesia in 2022, which reached 359 compared to the previous score of 371 in 2018. The report also noted a decrease in the numeracy score of students in Indonesia in 2022, which dropped to 366 from a score of 379 in 2018. Numeracy literacy, which involves recognizing, understanding, and using numbers in various contexts, is a significant key to meeting the challenges of solving mathematical problems (Dewi, 2023). A deep understanding of numeracy will help students transform information from problems into mathematical models correctly, minimizing calculation errors and increasing accuracy in mathematical calculations (Yusuf & Ratnaningsih, 2022).

Newman's procedure is an analytical method that can be used to investigate student errors. The systematic framework offered by the approach developed by Newman is used to determine the location, type, and component causes of errors. Newman's procedure analyzes errors in answering sentence-based problems (Prakitipong & Nakamura, 2006). Newman's error analysis involves five indicators: (1) Reading, (2) Comprehension, (3) Transformation, (4) Process Skills, and (5) Encoding (White, 2009).

This research is essential to understand better the types of errors students make in solving literacy and numeracy problems. Using the Newman Procedure, this study aims to identify the location, type, and cause of students' errors. The results are expected to provide useful insights for educators in designing more effective learning strategies to address these errors.

METHODS

This study uses qualitative research with a descriptive approach to analyze students' errors in solving literacy and numeracy problems based on

the Newman procedure (Kim, Sefick, & Bradway, 2017). The research subjects comprised six grade X students in Jakarta selected from 30 students. The data collection methods include giving literacy and numeracy tests and conducting interviews. The test instrument is literacy and numeracy description questions in the Algebra domain of Arithmetic and Geometric Rows material. The instrument's validity has been tested by mathematics education lecturer validators and empirically tested to ensure reliability and suitability to the level of student understanding.

After the data was collected, the analysis was carried out, which consisted of three stages: (1) data reduction, (2) data presentation, and (3) conclusion drawing. In the data reduction stage, researchers focused on relevant information and eliminated data that did not support the research. Information irrelevant or not supporting the research is removed to facilitate further analysis. At the data presentation stage, the literacy and numeracy problem work results are presented in images, while the interview results are presented as dialogue transcripts. This data presentation aims to visualize the errors made by students and provide a clear picture of the error pattern. At the conclusion stage, researchers describe students' errors in working on literacy and numeracy problems based on Newman's error indicators. The conclusion is drawn based on the analysis of the data that has been presented previously.

This study used the time triangulation method to ensure the validity of the data (Sugiyono, 2013). Time triangulation was done by testing the research sample at different times, with a three-day gap between the first, second, and third tests. The results of the three tests conducted at different times show the consistency of students' answers. Students' answers were corrected based on Newman's error indicators, shown in table 1.

Table 1. Newman Error Analysis Indicator

No.	Types of Error	Indicators
1.	Reading Error (RE)	a. Do not interpret the meaning of every word, term, or symbol in the problem b. Interpret the meaning of each word, term, or symbol, but not as requested in question c. Interpret the meaning of each word, term, or symbol in the question but less precisely d. Interpret the meaning of each word, term, or symbol in the question correctly

No.	Types of Error	Indicators
2.	Comprehension Error (CE)	a. Did not write down what was known and asked b. Writing the known and questioned but not precisely c. Writing the known and questioned but less precise d. Write the known questions correctly
3.	Transformation Error (TE)	a. No formula will be used to solve the problem b. A formula will be used to solve the problem, but it needs to be corrected c. A formula will be used to solve the problem, but less precise d. There is a formula that will be used to solve the problem correctly
4.	Process Skills Error (PE)	a. Did not write the computation process (calculation) b. Miswrite the calculation process, and the steps are not correct c. Write the calculation process and steps, but not quite right d. Write the calculation process correctly with the proper steps
5.	Encoding Error (EE)	a. Did not write the final answer by the conclusion referred to in the problem b. Incorrectly wrote the final answer by the conclusion referred to in question c. Write the final answer by the conclusion referred to in the question but less precise d. Write the final answer in the conclusion referred to in the question correctly

Source: Sunardiningsih, Hariyani and Fayeldi (2019)

After correcting the answers, six subjects were selected using the purposive sampling technique. Two subjects represented the high, medium, and low ability categories. Once the subjects were selected, interviews were conducted to gain a deeper understanding of the reasons behind the errors made by the students. The interviews helped identify problems that may not be apparent from the test results alone, such as misunderstanding concepts or difficulty in applying problem-solving strategies. The interviews were conducted in-depth and structured to ensure all aspects of the errors were

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properly identified. Subject selection criteria were based on literacy and numeracy test results measured through literacy and numeracy category intervals to help group students by ability level and ensure a balanced representation of each ability category, as shown in table 2 (Kurniawan & Munandar, 2022).

Table 2. Interval of Literacy and Numeracy Categories

Category	Interval
High	$X \geq (\bar{X} + SD)$
Medium	$(\bar{X} - SD) < X < (\bar{X} + SD)$
Low	$X \leq (\bar{X} - SD)$

Description:

X : Students' Score

$\bar{X}$: Mean

SD : Standard Deviation

RESULTS AND DISCUSSION

In this study, students' literacy and numeracy skills are categorized based on Newman's error analysis, which is divided into high, medium, and low categories. The results showed that this categorization was based on the test which was conducted three times with different time intervals. The analysis showed consistency in learners' responses, as illustrated in table 3.

Table 3. Literacy and Numeracy Category Results

Subject	Literacy and Numeracy Category Results		
	Meetings		
	1	**2**	**3**
S4	Medium	Medium	Medium
S12	High	High	High
S14	Low	Low	Low
S25	Low	Low	Low
S29	High	High	High
S30	Medium	Medium	Medium

Through this classification, the types of errors made by each subject in working on the four literacy and numeracy problems can be identified, which

include the stages of reading, comprehension, transformation, process skills, and encoding, as shown in table 4.

Table 4. Classification of Students' Errors Types

Category	Subject	Types of Error			
		Question Number			
		1	2	3	4
High	S12	-	-	2, 4, 5	-
	S29	-	-	2, 4, 5	-
Medium	S4	-	1, 2, 4, 5	1, 2, 4, 5	-
	S30	-	1, 2, 4, 5	1, 2, 4, 5	-
Low	S14	√	√	√	3, 4, 5
	S25	√	√	√	3, 4, 5

Description:

1, 2, 3, 4, 5   : Newman error indicators

√   : Subjects made all error indicators

−   : Subjects did not make any error

1. Results of Error Analysis of High Literacy and Numeracy Category

The analysis of errors in the category of students with high literacy and numeracy abilities by subjects S12 and S29 found that in questions 1, 2, and 4, both subjects did not make errors and could answer according to the indicators. The errors of subjects S12 and S29 were seen in question number 3, which had the same errors, namely errors in understanding, process skills, and encoding. The test was conducted three times, with an interval of three days, to check the consistency of student errors. The results showed that in the second test, subjects S12 and S29 made the same error in problem number 3, and in the third test, the error remained consistent in problem number 3. This shows that the error is persistent. The answers of subjects S12 and S29 in question number 3 can be seen in figure 1.

Figure 1. Answers to Number 3 Subjects S12 and S29

The comprehension errors are that subjects S12 and S29 have written the known and asked but need to be more precise. It can be seen that the two subjects incorrectly determined the value of "n". The results of the interview with subject S29 support this.

I : Why did you determine the value of "n" equal to 10?

S29 : Because in one hour he split twice and was asked the sum when five hours, I'm not careful, the answer should be 11 because it is added to the first term

The interview results with subject S29 needed a more thorough understanding of the problem. Subject S29 immediately concluded that the value was not realized, and the first term must also be calculated. This error is the same as the error made by subject S12, which needs to be understood in terms of what is known about the problem. Because of this, both subjects S12 and S29 made errors in their process skills; even though they had written down the calculation steps, they produced the wrong answer. When writing the answer, both included the final answer according to the conclusion in the question, but it needs to be more precise. It showed that subjects with high categories tended to make errors in only one problem at the stage of understanding, process skills, and encoding.

2. Results of Error Analysis of Medium Literacy and Numeracy Category

In the analysis of errors in the category of students with medium literacy and numeracy abilities by subjects S4 and S30, it was found that in questions 1 and 4, the two subjects did not make errors and could answer according to the indicators. The errors of subjects S4 and S30 are seen in questions 2 and 3, which are the same errors in reading, understanding, process skills, and encoding. The test was conducted three times with an interval of three days to see the consistency of student errors. In the second test, subjects S4 and S30 still made the same mistakes on questions 2 and 3. This error also occurred in the third test, indicating that this error was consistent. The error can be seen in figure 2, which is represented by number 2.

Figure 2. Answers to Number 2 Subjects S4 and S30

Reading and understanding errors made by subjects S4 and S30 are interpreting the meaning of each word, term, or symbol but less precisely. Both subjects have written what is known but must be more precise in determining the value of "n". The results of the interview with subject S4 support this.

I   : Why did you determine the value of n equal to 40?
S4   : Because in the question, there is a number 40 minutes

The interview results with subject S4 showed that the subject needed to be more careful in reading the problem. When subject S4 saw the number 40 in the issue, subject S4 immediately assumed that that was what was asked in the

situation, even though other words indicated that the number 40 was not what was meant. This caused the subject to make errors in determining the available information. Subject S30 experienced something similar to subject S4 in reading and understanding the problem. Due to errors in reading and comprehension, this resulted in errors in process skills and encoding. The results of the interview with subject S30 support this.

I : Why in the calculation part of $\frac{40}{2}(60 + 585)$ did you divide the number 60 with 2?

S30 : To make it simpler, I crossed out 60 with 2, so it equals 30 and formed into $40(30 + 585)$

The interview results with subject S30 showed that subject S30 made a process skill error with a fatal error. The calculation of $\frac{40}{2}(60 + 585)$ S30 needed to follow the correct sequence of mathematical operations by completing the operations inside the brackets first. Instead, subject S30 crossed out the number 60 with the number 2 to simplify the calculation without realizing it was an error. The process skill error can be seen from how subject S30 wrote down the incorrect calculation process and sequence of steps. Similar errors in process skills also occurred in subject S4, which resulted in errors in writing the answer even though the final answer was written. Still, it did not match the conclusion intended in the question. It showed that subjects with medium categories tended to make errors in two problems, namely numbers 2 and 3, both in the stages of reading, comprehension, process skills, and encoding.

3. Results of Error Analysis of Low Literacy and Numeracy Category

In the analysis of errors in the category of students with low literacy and numeracy abilities by subjects S14 and S25, it was found that both subjects made errors in each item. Subject S14 and S25 errors are seen in each problem with the same error. In questions 1, 2, and 3, subjects S14 and S25 made errors in reading, understanding, transformation, process skills, and encoding. In the second and third tests, subjects S14 and S25 consistently made the same mistakes in each problem. These errors included reading, comprehension, transformation, process skills, and encoding stages in problem numbers 1, 2, and 3, as well as transformation, process skills, and encoding in problem number 4. These errors can be seen in figure 3, represented by number 1.
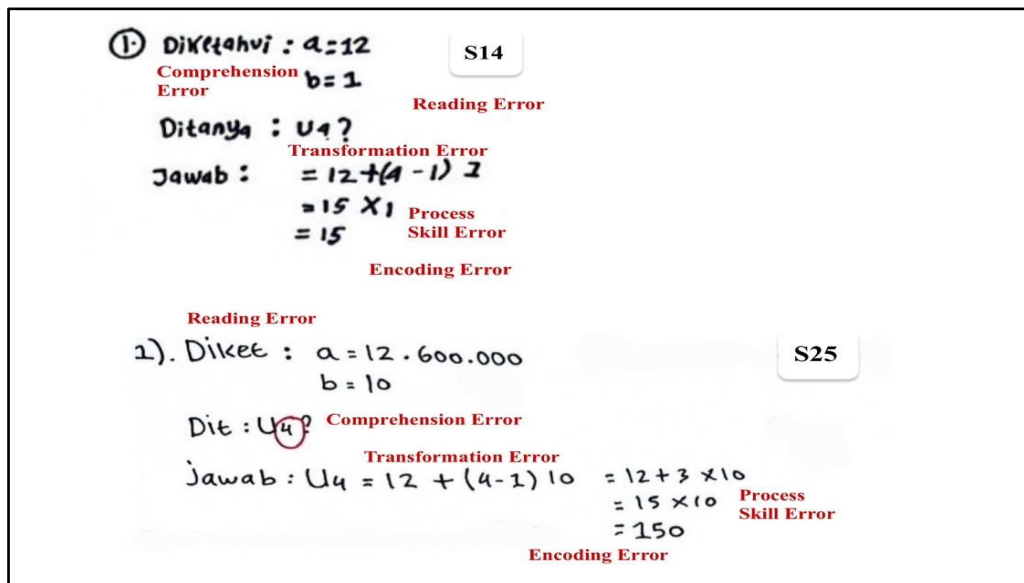
Figure 3. Answers to Number 1 Subjects S14 and S25

Reading and understanding errors made by subjects S14 and S25, it can be seen that both subjects did not interpret the meaning of each word, term, or symbol in the problem. Then, both subjects wrote what was known and asked about, but only some of it. The results of the interview with subject S14 support this.

I   : Can you read number 1?
S14   : Yes
I   : Then, why is the value of "a" is 12 and "b" is 1? While in the question, the numbers are 12.600.000 and 1.000.000
S14   : Oh, I read it wrong because I was in a hurry

The interview results showed that subject S14 misread the problem by writing the value of "*a*" equal to 12 and "*b*" equal to 1, even though the problem did not show these numbers. Subject S14 seemed to misread the situation due to needing to be in a hurry to answer the question. This was also done by subject S25, who wrote the value of "*b*" equal to 10. The error in reading the problem impacted understanding mistakes, namely, writing what was known and asked but needed to be corrected. Both subjects also made transformation errors because no formula could be used to solve the problem. This has an impact on process skills errors and encoding. The results of the interview with subject S25 support this.

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I   : Why does the $12 + 3 \times 10$ result become 15×10 in the calculation part?

S25   : Because I added it and then I multiplied it

The interview results showed that subject S25 made errors in process skills because he needed to understand the order of the calculation process in mathematics. Subject S25 appeared to perform the addition operation before continuing with the multiplication operation. A similar phenomenon was also seen in subject S14. Errors in encoding were also very striking, where both subjects needed to present the final answer by the conclusion requested in the problem. Then, for number 4, subjects S14 and S25 made the transformation, process skills, and encoding errors, as shown in figure 4.
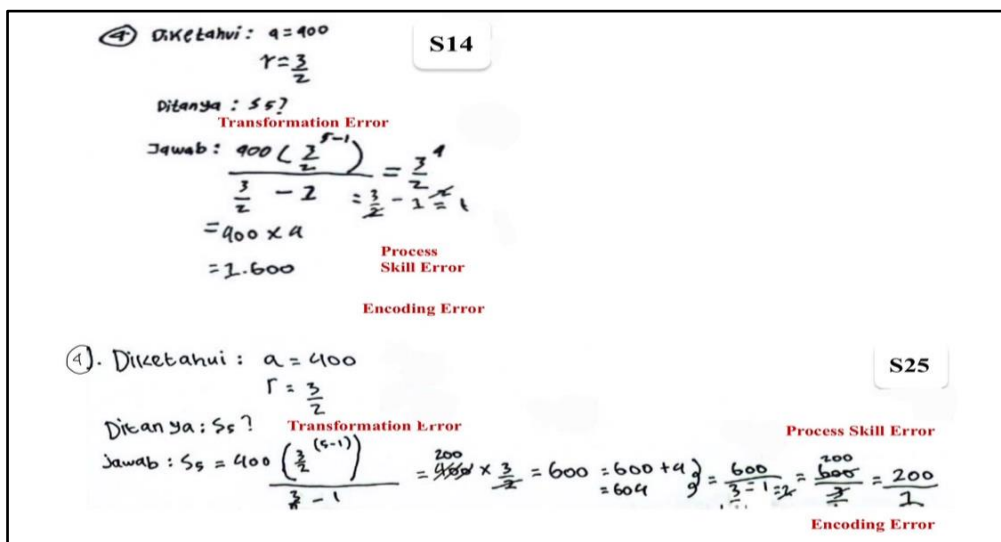

Figure 4. Answers to Number 4 Subject S14 and S25

The transformation error made by the two subjects is that no formula will be used to solve the problem. It can be seen from the calculation results or at the process skills stage that both subjects are wrong in the calculation process. In number 4, the two subjects did not write the final answer by the conclusion referred to in the problem. The results of the interview by subject S14 support this.

I   : Why did you get the result of 1600 in the calculation part of number 4?

S14   : Honestly, I did it randomly. I don't understand how to do power and division or fractions

I   : Why you didn't write the conclusion?

S14   : Because I am not used to writing the conclusion

The results of the interview with subject S14 showed that the subject needed help understanding how to calculate problem number 4 because there were operations of multiplication, fractions, and division. This can also be seen in the results of subject S25, who could not perform the calculation correctly. Errors in writing answers by both subjects occurred because they were not used to writing conclusions on math problems. Subjects in the low category tend to make errors at all stages, including reading, comprehension, transformation, process skills, and encoding errors.

Based on the results of the analysis, it is found that there are differences in the number of mistakes and error indicators made by subjects with each category. AL-Ashri and Awalludin (2023) also revealed that subjects in the high, medium, and low categories experience varying levels of difficulty. The research of Fitri, Subarinah, and Turmuzi (2019) concluded that the higher the student's ability, the better the student's reading ability and transformation ability in remembering and using the formula needed to solve the problem. Subjects with high categories tend to make comprehension errors in line with the research of Mursyidah, Lidinillah, and Muharram (2023), in which students need help understanding the problem, so the solution method is incorrect. Putri and Purwanto (2022) found errors in the stages of encoding and process skills in high-category subjects; this was caused by students needing to solve the problem carefully and writing the wrong conclusion at the end of the answer.

Suardi, Hakim, and Aziz (2022) stated that subjects with medium categories made comprehension errors because the subjects did not understand the information in the problem. This is reinforced by the interview results, which show that students need help understanding what is known and asked about the issue. Additionally, students in the medium category make process skill errors because they struggle with following the correct procedures or steps. Encoding errors also occur because students struggle to find the final result using the given method and cannot present the final answer to the problem-solving, as explained in the research (Sunardiningsih, Hariyani, & Fayeldi, 2019).

According to Oktaviani, Kintoko, and Suprihatiningsih (2021), students who experience many errors are those in the low category because there are

errors in all error indicators. This discovery aligns with the study's results, which show that subjects in the low category made errors at all stages. Anggreni, Pudpadewi, and Noviyanti (2020) also demonstrated that students in the low group are prone to making errors in reading, comprehension, transformation, process skills, and encoding.

CONCLUSION

Students with high, medium, and low literacy and numeracy tend to make errors at each stage of Newman's errors, namely reading, understanding, transformation, process skills, and encoding. The difference in the errors of each ability lies in the number of mistakes and error indicators made. In high categories, students made errors in one literacy and numeracy problem with three error indicators, namely: (1) Comprehension, writing what is known and asked but is less precise on the known part due to lack of accuracy; (2) Process Skill, writing the process and calculation stages but less precisely due to errors in comprehension indicators; and (3) Encoding, writing the final answer by the conclusion referred to in the problem but is less precise due to answer errors. Medium categories students made errors in two literacy and numeracy problems with four error indicators, namely: (1) Reading, not interpreting the meaning of each word, term, or symbol in the problem; (2) Comprehension, writing what is known and asked but not precise in the known part because they are not careful about what they read; (3) Process Skill, writing the process and stages of calculation but not precise and wrong in the operation; and (4) Encoding, incorrectly writing the final answer according to the intended conclusion in the problem due to errors in determining what is known and the calculation process. In low categories, students made errors in all literacy and numeracy problems with all error indicators, namely: (1) Reading, not interpreting the meaning of each word, term, or symbol in the problem because they misread the problem; (2) Comprehension, writing the known and questioned but not precise; (3) Transformation, no formula will be used to solve the problem because they do not know what formula to use; (4) Process Skill, writing the process and stages of calculation but not precise and incorrect in its operation; and (5) Encoding, not writing the final answer according to the conclusion referred to in the problem because they are not used to it.

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