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Analysis of Students' Errors in Solving Mathematical Literacy Problems Based on Newman Procedure and Self-Efficacy

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ABSTRACT

Low mathematical literacy among Indonesian students indicates that students still experience difficulties in understanding contextual information, representing it in mathematical models, and determining appropriate solution strategies. These difficulties may result in different patterns of errors and may be associated with students' self-efficacy. This study aimed to describe students' errors in solving mathematical literacy problems in algebra based on the Newman Procedure and self-efficacy. The study employed a descriptive qualitative approach involving eighth-grade students at SMP Negeri 1 Makassar during the 2025/2026 academic year. Six students were purposively selected, with two students representing each self-efficacy category: high, moderate, and low. Data were obtained through a self-efficacy questionnaire, a diagnostic mathematical literacy test, and semi-structured interviews. The questionnaire was used to determine the students' self-efficacy categories, after which the selected participants completed the diagnostic test and were interviewed to explore their problem-solving processes. Data were analyzed through data condensation, data display, and conclusion drawing. The findings revealed different patterns of errors across self-efficacy levels. Students with high self-efficacy were able to read and comprehend the problems well but still made errors in the transformation, process skills, and final answer encoding stages. Students with moderate self-efficacy made errors across all Newman stages, particularly in interpreting symbols and information, constructing mathematical models, and carrying out calculations. Meanwhile, students with low self-efficacy demonstrated more complex and continuous error patterns, beginning at the reading stage and affecting subsequent stages of problem solving. These findings indicate that self-efficacy levels are associated with the characteristics and complexity of students' errors; therefore, error diagnosis should be used to design instructional support that addresses students' needs at each stage of problem solving.

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Introduction

Mathematical literacy is an important competency in mathematics education because it is related to students' ability to understand, use, and apply mathematical concepts in various real-life situations. This ability requires not only mastery of mathematical concepts and computational skills but also the ability to understand information in context, select appropriate strategies, and use mathematics to solve problems (Almadani & Wulandari, 2024; Fajriyah, 2022; Lestari & Effendi, 2022). However, students' mathematical literacy in Indonesia remains relatively low. The results of the PISA study show that Indonesia's mathematical literacy score is below the international average. Moreover, the score decreased from 379 in 2018 to 366 in 2022, although Indonesia's ranking improved (OECD, 2023). This situation indicates that students still face difficulties in understanding and applying mathematical concepts in real-world contexts (Angriani et al., 2024; Heryani et al., 2024; Ramadhani et al., 2023; Usman et al., 2024).

One way to understand these difficulties is through analyzing the errors students make when solving problems. Error analysis not only reveals incorrect final answers but also provides insight into students' thinking processes. This information is important for teachers to identify where students experience difficulties and to design more appropriate instruction (Nainggolan & Listiani, 2024; Peltier & Peltier, 2020). In the context of mathematical literacy problems, errors may occur when students are required to understand contextual information, relate it to mathematical concepts, and determine appropriate procedures. These conditions become more complex in algebra because students need to translate real-life situations into mathematical symbols or models and perform procedural manipulations to obtain a solution (Oktavira et al., 2021; B. A. Putri et al., 2021).

Field findings indicate that these difficulties also occur among students at SMPN 1 Makassar. Based on observations and interviews with mathematics teachers, of the 535 students who participated in a mathematics test based on mathematical literacy, only 15% obtained scores above the minimum passing criterion (KKM) of 75. Meanwhile, in a daily assessment on algebra, of the 144 students who took the test, only 31 students obtained scores above the KKM of 75 (Dokumen SMPN 1 Makassar, 2024). Thus, 85% of students had not reached the KKM in the mathematical literacy test, while approximately 78.5% had not reached the KKM in the daily assessment on algebra. These findings indicate that students' difficulties are related not only to conceptual understanding but also to their ability to apply concepts in solving problems.

In addition to cognitive factors, affective factors such as self-efficacy also influence students' success in learning mathematics. Self-efficacy refers to an individual's belief in their ability to accomplish a particular task. Students with high self-efficacy tend to demonstrate greater persistence when facing difficulties, select strategies they consider appropriate, and attempt to check or improve their solutions when encountering obstacles. Conversely, students with low self-efficacy tend to give up more easily, avoid tasks they perceive as difficult, or make less effort when encountering errors (Bandura, 1997). Several studies have shown that the level of self-belief is associated with students' ability to solve mathematical problems, including literacy-based problems (Nurtiana & Adirakasiwi, 2022; A. E. Putri et al., 2024; Wulanningtyas & Ate, 2020).

To identify students' errors in greater detail, this study employs the Newman Procedure, which consists of five stages: reading, comprehension, transformation, process skills, and encoding (Clements & Ellerton, 1996). This procedure enables researchers to determine the stage at which errors occur during the problem-solving process. Several studies have used the Newman Procedure to examine students' errors in various mathematical topics, such as

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sequences and series, plane geometry, and sets (Annisa & Kartini, 2021; Noutsara et al., 2021; Wahyuni et al., 2024). These studies indicate that errors may occur at different stages depending on the characteristics of the problems and students' abilities. Meanwhile, studies related to self-efficacy have focused more on its relationship with students' ability to solve mathematical literacy problems (Angriani et al., 2024). This condition indicates that a study specifically mapping error patterns at each stage of the Newman Procedure in solving mathematical literacy problems in algebra based on self-efficacy categories is still needed. Therefore, this study not only identifies the types of students' errors but also compares the characteristics of error patterns among students with high, moderate, and low self-efficacy

Based on the discussion above, this study aims to analyze students' errors in solving mathematical literacy problems in algebra based on the Newman Procedure and to examine how these errors differ according to students' levels of self-efficacy. The findings are expected to provide diagnostic information for mathematics instruction, particularly by identifying the stages and patterns of errors that require teachers' attention, so that instructional support can be adapted to the characteristics of students' errors in each self-efficacy category.

Method

Research Type

This study employed a qualitative research design with a descriptive approach, which aimed to describe students' errors and the causes of errors at each stage of the Newman Procedure when solving mathematical literacy problems in algebra. In this qualitative study, the researcher served as the primary instrument and was able to interact directly with the participants to identify factors related to students' errors.

Subjects

The subjects of this study were eighth-grade students at SMP Negeri 1 Makassar in the 2025/2026 academic year who had studied algebra. The research subjects were selected based on the results of the students' mathematical self-efficacy questionnaire. The self-efficacy categories referred to the modified categories of Baihaki et al. (2022) , namely high ($80\% \leq X \leq 100\%$), moderate ($60\% \leq X < 80\%$), and low ($0\% \leq X < 60\%$), where X represents the percentage of students' self-efficacy scores. Based on this mapping, six students were selected as research subjects according to their self-efficacy category, communication skills, completeness of responses, willingness to participate in interviews, and teacher recommendations. Two students were selected from the high self-efficacy group based on the highest scores, two students from the moderate group based on the middle positions after the scores were ranked, and two students from the low group based on the lowest scores.

Instruments

The research instruments consisted of the researcher as the primary instrument and supporting instruments, including a self-efficacy questionnaire, a diagnostic test, and an interview guide. The questionnaire consisted of 20 statements designed to identify students' levels of self-efficacy in learning mathematics. The diagnostic test consisted of three mathematical literacy essay problems in algebra designed to identify students' errors based on the stages of the Newman Procedure. The problems were presented in everyday-life contexts and required students to understand information, translate the context into mathematical models, apply algebraic concepts, perform calculations, and interpret the results. The three problems covered algebraic content and were designed to elicit all five stages of the Newman Procedure. The use of three problems was considered appropriate because the study focused on in-depth analysis through students' written responses and interviews rather than on quantitatively measuring their abilities. All instruments underwent validation by two experts in mathematics education before being used. The indicators of errors examined in this study are presented in Table 1

Table 1. Description of Task and Indicators of Students' Errors Based on the Newman Procedure

No	Newman Procedure	Error Indicators	Examples of Errors
1.	Reading or Decoding	a. Unable to read words/symbols/units correctly. b. Misinterprets the meaning of the words/symbols/units read.	a. Reading $\frac{2}{5}$ as "two five". b. Considering $\frac{1}{4}$ of the pocket money as a specific monetary value rather than as a part of the total amount.
2.	Comprehension	a. Does not fully understand the content and purpose/meaning of the problem. b. Incorrectly identifies the given or required information. c. Misinterprets the relationships among the data in the problem.	a. Does not understand that the problem asks for the remaining amount or a specific quantity based on the information provided. b. Considers the remaining amount as the initial amount of money or incorrectly identifies the quantity being asked. c. Interprets "the width is 6 m shorter than the length" as the width being 6 m.
3.	Transformation	a. Unable to correctly translate the information in the problem into a mathematical model. b. Selects an inappropriate formula/operation/solution strategy.	a. Does not translate the relationships among the quantities in the problem into an equation, inequality, or algebraic model. b. Uses an equation for a situation that should be modeled using an inequality.
4.	Process Skills	a. akes errors in calculations or algebraic manipulation. b. Does not complete the calculation procedure correctly or completely.	a. Performs fraction operations and algebraic manipulations using incorrect steps. b. Stops at a particular algebraic form and does not continue until obtaining the value of the variable.
5.	Encoding (Writing the Answer)	a. Does not present the result in the form or context required b. Uses incorrect units, symbols, or answer formats.	a. Writes the calculation result without a conclusion that answers the question in the problem. b. Uses a unit that does not correspond to the quantity asked or omits the unit.

Source: Clements & Ellerton (1996); White (2010)

Data Collecrtion

Data collection was carried out in three stages: preparation, implementation, and completion. During the preparation stage, the researcher conducted preliminary observations at the school, prepared the research proposal, developed the instruments, and conducted instrument validation. The implementation stage began with administering the self-efficacy questionnaire to determine students' self-efficacy categories. Six students representing the high, moderate, and low categories were then selected as research subjects, followed by the administration of the diagnostic mathematical literacy test in algebra. The students' work was

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https://doi.org/10.51574/kognitif.v6i3.5055 Volume 6, No 3, July - September 2026, pp. 1458 –1473

subsequently analyzed based on the stages of the Newman Procedure to identify the types of errors made. Semi-structured interviews were then conducted with each participant for each test item to explore their thinking processes and clarify the errors identified. The interviews were conducted in Indonesian for 20–30 minutes in one session for each participant, recorded, and transcribed for analysis. After all data had been collected, data validity was checked through triangulation. Finally, the completion stage involved preparing and writing the research report. The research data collection flow is presented in Figure 1.

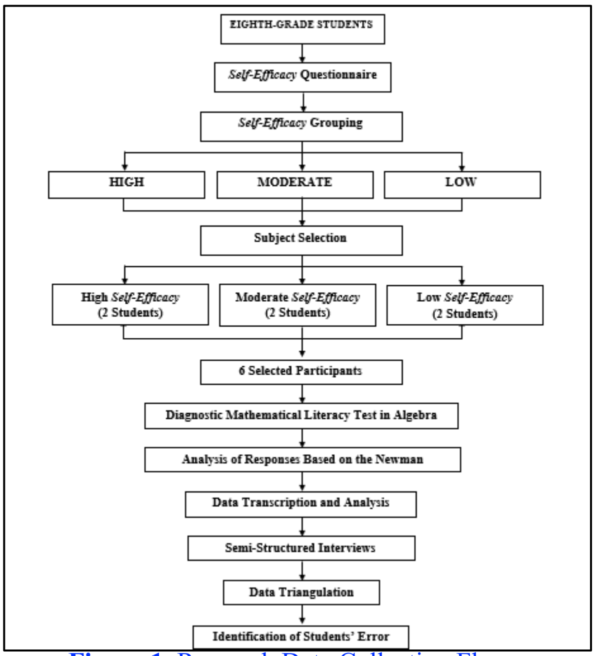

Figure 1. Research Data Collection Flow

Data Analysis

The data analysis technique in this study referred to the Miles & Huberman (2014) model, which consists of data condensation, data display, and conclusion drawing. During data condensation, the researcher reduced data from the questionnaire, test results, and interview transcripts into data ready for analysis. The test and interview data were then coded based on self-efficacy category, item number, and stage of the Newman Procedure, and grouped according to types of errors with similar characteristics. Data display was carried out by presenting students' written responses and interview results according to these categories to identify patterns and differences in errors across participants. Subsequently, conclusion drawing and verification were conducted by interpreting the meaning of the data and comparing error patterns across participants within each self-efficacy category.

Results

The students' self-efficacy grouping was determined based on the results of the questionnaire administered to eighth-grade students at SMP Negeri 1 Makassar. The categorization results showed that, of all students who completed the questionnaire, 25 students were classified as having high self-efficacy, 248 students as moderate, and 45 students as low. Based on these results, six students were selected as research participants to complete the diagnostic test and participate in in-depth interviews. The details of the research participants are presented in Table 2.

Table 2. Research Participant Selection

No	Student Initials	Student Self-Efficacy Category	Student Code
1.	IPI	High	T1
2.	FRM	High	T2
3.	GAKR	Moderate	S1
4.	EKLA	Moderate	S2
5.	ALML	Low	R1
6.	IRR	Low	R2

The results of the diagnostic mathematical literacy test in algebra and the interviews at each self-efficacy level are presented as follows:

Errors of Students with High Self-Efficacy

Students with high self-efficacy demonstrated good ability to understand the problems and identify the information presented in the mathematical literacy problems. Based on the analysis of written responses and interview results, neither of the two participants made errors at the reading and comprehension stages. The participants were able to read mathematical symbols and terms correctly and identify the given and required information in the problems. Nevertheless, errors were still found at the transformation, process skills, and encoding stages.

At the transformation stage, an error was found in T1 when solving a problem related to purchasing stickers. The participant used an equation model for a situation that should have been modeled using an inequality. T1 initially wrote the mathematical model as $70.000 - 2.000 = 8.000x$, and only changed it into an inequality at the end of the solution (Figure 2). This finding was supported by the following interview.

P : *Why did you change the mathematical model from an equation to an inequality?*

T1 : *At first, I used an equation model as usual. However, because the result of the division was not a whole number, I used an inequality instead (T1-215)*

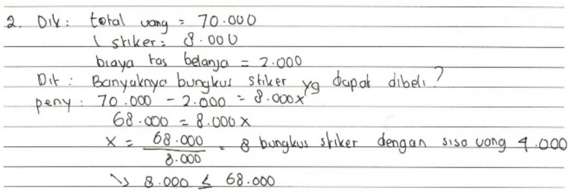

Figure 2. T1's Response to Question 2

This finding indicates that the transformation error occurred because the participant had not yet adjusted the mathematical model to the context of the given problem. At the process skills stage, the two participants demonstrated errors with different causes. T1 made an error due to carelessness in writing the algebraic expression. During the solution process, the participant omitted the variable x resulting in an incomplete calculation step. When asked about this step, T1 stated, "*It should have been 8,000x ≤ 68,000, Ma'am.*" (T1-218). The participant actually understood the intended solution but forgot to write the variable completely because of being too focused on the final result. Meanwhile, T2 experienced difficulty in carrying out algebraic manipulations involving fractions. In one of the problems, the participant stopped at the expression $\frac{7}{20}x = 21.000$ and was unable to continue the solution process to obtain the value of the variable. T2's written response is presented in Figure 3.

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
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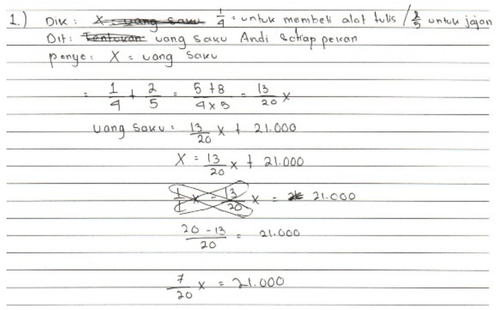

Figure 3. T2's Response to Question 1

T2's difficulty in solving the algebraic expression was further supported by the following interview.

P : *Then, how do you determine the value of x?*

T2 : *I know that x is the amount of pocket money, but I do not know how to solve this expression* $\frac{7}{20}x$ *(T2-115).*

Based on the interview results, T2's process skills error was caused by difficulty in performing algebraic manipulations involving fractions. Errors were also found at the encoding stage. T1 several times failed to write a final conclusion or the appropriate unit, even though the participant had obtained the correct calculation result. The participant stated that they forgot to write the conclusion because they felt that the solution process already sufficiently showed the intended answer. Meanwhile, for T2, the encoding error occurred as a result of the inability to complete the calculation process at the previous stage, so the participant did not obtain a final result to be written.

Errors of Students with Moderate Self-Efficacy

Students with moderate self-efficacy demonstrated varying abilities in solving mathematical literacy problems. Based on the analysis of written responses and interview results, some participants were able to understand the basic information in the problems but still made errors at the reading, comprehension, transformation, process skills, and encoding stages. The errors made by each participant had different characteristics.

At the reading stage, errors were found in both participants, particularly in interpreting mathematical symbols and contextual terms in the problems. S1 experienced difficulty understanding the meaning of the fractions $\frac{1}{4}$ and $\frac{2}{5}$ in the context of pocket money. The participant considered the fractions to represent specific monetary values without understanding that the fractions represented parts of a whole. Meanwhile, S2 experienced difficulty not only in understanding fraction symbols but also in interpreting the terms "every week" and the phrase "shorter than the length." The participant interpreted "every week" to mean that the final result should be multiplied by seven because a week consists of seven days, and directly interpreted the width of the land as 6 meters. This was supported by the following interview.

P : *What do you mean by "every week"?*

S2 : *I was confused about whether the final result was for one week or whether it had to be multiplied by seven because a week consists of seven day (S2-103)*

S2's written response is presented in Figure 4.

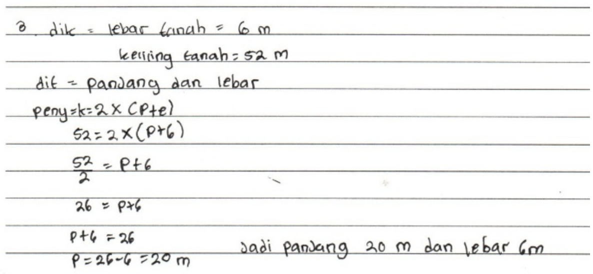

Figure 4. S2's Response to Question 3

The errors at the reading stage indicate that the difficulties experienced by the students did not lie in their ability to read the problem text, but rather in their ability to interpret mathematical symbols and the contextual language used in the problems.

At the comprehension stage, errors were more prominent in S2. The participant was unable to understand the relationships among the information in the problem and therefore interpreted that all the numbers in the problem could be added directly to obtain the answer. In addition, the participant also misunderstood the relationship between the length and width of the land in the rectangle perimeter problem. In contrast, S1 was generally able to identify the given and required information and explain the relationships among the data in the problem fairly well. This indicates that comprehension errors among students with moderate self-efficacy tended to be influenced by errors at the preceding reading stage.

At the transformation stage, both participants showed relatively consistent errors. S1 made errors in constructing mathematical models, such as using addition in a situation that should have been modeled using subtraction or an inequality. In one of the problems, the participant wrote the mathematical model as $x + \frac{13}{20}x = 21.000$ (Figure 5), whereas the appropriate model should have represented the relationship among the pocket money, the amount spent, and the remaining money. In addition, the participant incorrectly determined the result of adding fractions because the participant considered the process to be "cross multiplication."

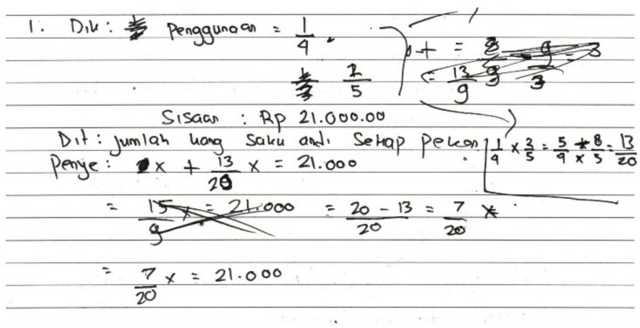

Figure 5. S1's Response to Question 1

Meanwhile, S2 demonstrated a transformation error by not using a formal mathematical model and instead choosing a simple arithmetic strategy that was inconsistent with the algebraic concept. In one problem, the participant initially wrote $\frac{1}{4}x + \frac{2}{5}x$, but then crossed it out and directly added all the numbers in the problem (Figure 6). In another problem, the participant also did not use an inequality even though the problem concerned the maximum amount of money available. In the interview, S2 stated, "*I did not think of using algebra.*" (S2-210).

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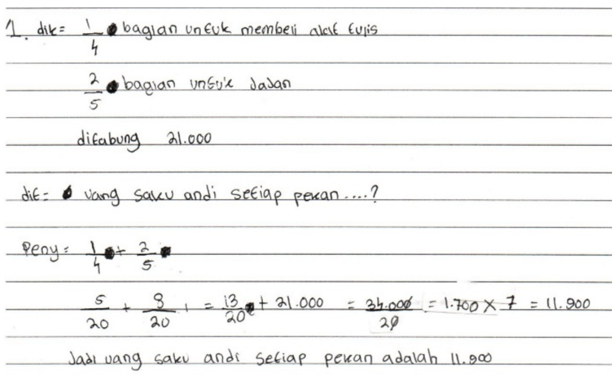

Figure 6. S2's Response to Question 1

These findings indicate that students with moderate *self-efficacy* were not yet able to accurately transform contextual problems into mathematical models. This error was influenced by limited understanding of algebraic concepts, uncertainty in using variables, and a tendency to use practical strategies that were considered easier.

At the process skills stage, both participants also experienced errors in different forms. S1 had difficulty completing algebraic manipulations involving fractions. In one of the problems, the participant stopped at the expression $\frac{7}{20}x = 21.000$ and was unable to continue the solution procedure until obtaining the value of the variable. Based on the interview results, the participant reported being confused about solving equations with fractional coefficients and being more accustomed to solving simple equations. Meanwhile, S2 made a procedural error in performing fraction operations. The participant added $\frac{13}{2} + 21.000$ by directly adding the numerator of the fraction to the whole number, resulting in an incorrect form. These errors indicate that the procedural skills of both participants were not yet stable, particularly when performing algebraic operations involving fractions and non-routine forms.

Errors were also found at the encoding stage. S1 did not write a final answer because the participant was unable to complete the calculation process at the previous stage. Meanwhile, S2 wrote an answer that was inconsistent with the context of the problem and did not provide the appropriate unit in the final answer. Based on the interview results, the participant reported being uncertain about the answer obtained and considered writing the unit to be relatively unimportant. This indicates that encoding errors among students with moderate *self-efficacy* were generally a consequence of errors at the preceding stages, as well as a lack of accuracy in presenting the final answer.

Errors of Students with Low *Self-Efficacy*

Students with low *self-efficacy* demonstrated limited ability to solve mathematical literacy problems in algebra. Based on the analysis of written responses and interview results, both participants made errors at almost all stages of the Newman Procedure. The errors tended to be interconnected, with errors at the initial stages affecting the subsequent stages. Nevertheless, under certain conditions, the students were still able to understand simple contexts and perform basic arithmetic calculations when using concrete strategies such as trial and error or direct calculation.

At the reading stage, both participants made errors, particularly in problems involving fractions. R1 was able to read the problem fluently but did not yet understand the meaning of fractions as parts of a whole. The participant reported being confused about the fractions $\frac{1}{4}$ and $\frac{2}{5}$, particularly in understanding the relationship between the fractions and the unknown total amount of pocket money. This was evident from the following interview.

P : *Which part confused you?*
R1 : *The fraction part. For example, one-fourth, if the money is ten thousand, then it is divided by four. But I am still confused about two-fifths. (R1-103)*

Meanwhile, R2 experienced a more fundamental error, namely an error in reading the fraction symbol. R2 read $\frac{2}{5}$ as "one-half over five" and considered this reading to be the same as "two-fifths." In addition, the participant did not yet fully understand the meaning of fractions. Thus, the reading errors made by both participants were related to their inability to interpret fraction symbols.

At the comprehension stage, both participants also showed relatively similar errors. Although they were able to state the given and required information, both participants were not yet able to understand the overall meaning of the problems or accurately interpret the relationships among the information. R1 assumed that all the given information could be directly added to obtain the total amount of pocket money, whereas R2 was confused because the problem provided only parts of the pocket money without directly stating the total amount. The comprehension errors indicate that both participants were not yet able to connect the information in the problems into a complete mathematical relationship. These errors were also a consequence of errors at the reading stage, particularly in understanding the concept of fractions as parts of a whole.

At the transformation stage, both participants made errors in converting the information in the problems into appropriate mathematical models. R1 tended to add all the given information without considering the mathematical relationship that should have been established. In Question 1, the participant wrote $\frac{1}{4} + \frac{2}{5} + 21.000$ because they assumed that all the information could be directly added to obtain the total amount of pocket money (Figure 7). Meanwhile, R2 attempted to use the symbols x and y, but was unable to construct an appropriate mathematical model (Figure 8). The variables were written randomly without a clear understanding of the underlying concept. R1's difficulty in using an algebraic model was also evident in the following interview.

P : *This problem involves algebra. Did you not try to solve it using an algebraic approach?*
R1 : *I do not really understand algebra. I have also forgotten it, so I only wrote down what I knew up to that point. (R1-116)*

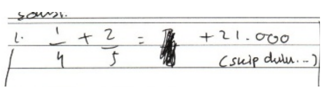

Figure 7. R1's Response to Question 1

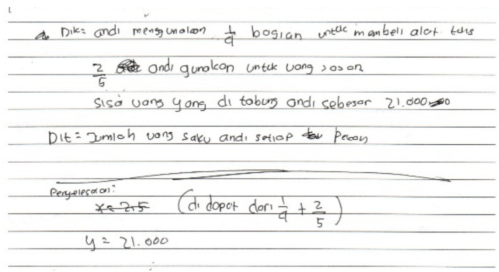

Figure 8. R2's Response to Question 1

Transformation errors were also found in Questions 2 and 3. Neither participant used a formal algebraic model; instead, they chose simple strategies such as direct addition, trial and error, or manual calculation. In Question 2, both participants preferred to use repeated

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multiplication to determine the number of sticker sheets that could be purchased rather than constructing an inequality model. In Question 3, both participants experienced difficulty converting the relationship between the length and width into an appropriate mathematical model. Based on the interview results, the transformation errors were caused by the students' limited ability to translate contextual problems into formal mathematical representations. Both participants also showed a tendency to rely on examples they had previously learned. When the form of the problem differed from previous examples, the students became confused and were unable to construct mathematical models independently.

At the process skills stage, both participants also experienced errors. In Question 1, R1 made an error in fraction operations and at one point added $\frac{1}{4} + \frac{2}{5}$ to obtain $\frac{3}{9}$. After realizing that the result was incorrect, the participant stopped the solution process and did not continue working on the problem. Meanwhile, R2 was unable to perform fraction operations correctly and only wrote $x = 2{,}5$ without a clear basis for the calculation. Process skills errors were also found in Question 3. R1 stopped at assigning values to the length and width without continuing with further algebraic manipulation. Meanwhile, R2 performed arithmetic calculations that were operationally correct but inconsistent with the relationship between the length and width stated in the problem. In addition to weak mastery of prerequisite material, both participants tended to stop solving when they encountered problems that they considered difficult or different from previously learned examples. This was evident in R1's statement below.

P : *Why did you not continue the solution?*

R1 : *I did not know the next step. I felt that I could not solve it, and I had never encountered a problem like this before. (R1-115)*

Thus, the errors at the process skills stage were related to weak mastery of prerequisite material, particularly fraction operations and algebraic manipulation, as well as difficulty continuing a solution strategy when faced with unfamiliar problem forms.

At the encoding stage, both participants again demonstrated errors. In several problems, the participants did not write a final answer because they were unable to complete the preceding solution process. In addition, errors were also found in the use of units and the context of the answers. In Question 2, R1 wrote the answer "8 sheets," whereas the problem asked for the number of "sticker packs." Meanwhile, in Question 3, R2 wrote a final answer that was inconsistent with the conditions of the problem because the participant only checked whether the perimeter was consistent without checking the relationship between the length and width.

Discussion

Based on the research findings, variations were observed in the errors made by students in solving mathematical literacy problems in algebra across the self-efficacy categories based on the Newman Procedure. The differences were particularly evident in the stages at which errors occurred. Students with high self-efficacy tended to be able to pass through the reading and comprehension stages but still made errors in transformation, process skills, and encoding. Meanwhile, students with moderate and low self-efficacy demonstrated errors across a wider range of stages. This pattern indicates that self-efficacy is associated with students' readiness to engage with a task, but it is not the only factor determining the accuracy of problem solving, as conceptual understanding and procedural skills also play important roles.

Among students with high self-efficacy, errors were generally not found at the reading and comprehension stages. This finding is consistent with several previous studies (Puspitaningati et al., 2024; Salsabilah & Kurniasih, 2022; Sarah et al., 2023). The ability to pass through the initial stages suggests that confidence in one's abilities may help students deal with the information presented in problems. However, high self-efficacy does not guarantee accuracy at stages that require mathematical modeling and manipulation. Transformation errors indicate a tendency to use familiar procedures without considering the characteristics of the context, whereas process skills errors are related to accuracy and mastery of algebraic manipulation. This finding is consistent with previous studies (Nurfalah et al., 2021; Puspitaningati et al., 2024; Sarah et al., 2023). The implication is that students with high self-efficacy need practice in translating various contexts into mathematical models, reinforcement of algebraic operations, and habituation to checking their results, units, and the consistency of their answers with the questions.

Among students with moderate self-efficacy, errors were found at several Newman stages, with varying levels of ability. This condition indicates that students had the ability to initiate the solution process but were not yet consistent in connecting contextual information with mathematical models and solution procedures. Errors in interpreting fraction symbols could affect comprehension and subsequently lead to errors in transformation and process skills. This finding is consistent with previous studies (Fimillatika & Haerudin, 2023; Puspitaningati et al., 2024; Sarah et al., 2023). Instruction for this group should emphasize gradual practice in translating contexts, beginning with identifying information, determining relationships among the information, defining variables, and constructing mathematical models. Practice with algebraic operations in various contexts is also needed so that students do not become dependent on previously demonstrated procedures

Meanwhile, students with low self-efficacy demonstrated errors at all Newman stages. This pattern was not only related to low confidence in their abilities but also to weak mastery of prerequisite concepts and limited experience in dealing with non-routine problems. Errors in interpreting fractions at the reading stage could hinder comprehension and subsequently make it more difficult to construct mathematical models, carry out calculations, and encode the final answer. This finding is consistent with previous studies (Burhanuddin et al., 2023; Hatta et al., 2021; Ningsih et al., 2020; Nurfalah et al., 2021). The implication is that instruction should begin with strengthening students' understanding of fractions and the meaning of mathematical symbols, followed by practice in understanding relationships among information, translating contexts into simple mathematical models, and strengthening algebraic operations. Providing problems gradually, from simple to more complex forms, along with feedback on the solution process, is also needed to build students' experiences of success. Overall, errors at the Newman stages tended to be interconnected, but this relationship was not absolute. Errors at an earlier stage may increase the likelihood of errors at subsequent stages, whereas mastery of particular concepts and strategies may still enable students to overcome difficulties at certain stages. Therefore, self-efficacy needs to be considered together with cognitive factors, particularly mastery of prerequisite material, modeling ability, accuracy, and experience in solving non-routine problems.

Conclusion

Based on the research findings, patterns of students' errors were identified in solving mathematical literacy problems in algebra based on the Newman Procedure across different self-efficacy categories. Students with high self-efficacy tended to be able to pass through the reading and comprehension stages but could still experience errors in transformation, process

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skills, and encoding, particularly in mathematical modeling, algebraic manipulation, and presenting results in accordance with the context. Students with moderate self-efficacy demonstrated errors across all Newman stages with more varied patterns, ranging from interpreting symbols and information, constructing mathematical models, and carrying out calculations to encoding the final answer. Meanwhile, students with low self-efficacy demonstrated errors across all Newman stages that tended to be interconnected, particularly in interpreting fraction symbols, comprehending the context, constructing algebraic models, performing calculations, and checking the consistency of the answer with the context of the problem. These findings describe error patterns based on self-efficacy categories and are not intended to indicate a causal relationship between self-efficacy and students' errors

The instructional implications of these findings are that teachers need to provide practice that is specific to students' error patterns. Strengthening algebraic modeling and practicing the translation of contexts into mathematical symbols are needed to address transformation errors. Practice in reading and interpreting mathematical symbols, particularly fractions, should be provided contextually for students who experience errors at the reading and comprehension stages. Strengthening algebraic operations and manipulation is needed to address errors at the process skills stage, while habituating students to check their results, units, and the consistency of their answers with the context is needed to reduce errors at the encoding stage. Teachers should also provide support and constructive feedback so that students become more confident and persistent when facing challenging problems. This study was limited to six participants from one school, three problems, and one mathematical topic, and did not specifically control for students' initial mathematical ability. Future research is recommended to involve more participants, multiple schools and mathematical topics, and to include initial mathematical ability as a comparison factor.

Conflict of Interest

The authors declare no conflict of interest.

Auhor Contributions

N.R. conceptualized the research idea presented and collected the data. The other two authors (B.I.S. and J.) actively contributed to the development of the theory, methodology, data organization and analysis, discussion of the results, and approval of the final version of the work. All authors confirm that they have read and approved the final version of this manuscript. The percentage contributions for the conceptualization, drafting, and revision of this paper are as follows: N.R.: 40%, B.I.S.: 30%, and J.: 30%.

Data Availability Statement

The authors state that the data supporting the findings of this study will be made available by the corresponding author, N.R., upon reasonable request.

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