Beyond Symbolic Identification: Assessing the Gap Between Procedural Numeracy and Structural Sense in Linear Equations

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ABSTRACT

This research explores the numeracy skills and conceptual understanding of students regarding Linear Equations in Two Variables (LETV). Employing a descriptive qualitative method, the study involved 30 Class VIII-C students at 1 Kasihan State Junior High School. Data were collected through a validated test featuring five essay questions designed to measure four indicators: variable identification, equation construction, value determination, and contextual decision-making Results indicate that 60% of students possess high ability, 33.33% medium ability, and 6.66% low ability. While students excelled in identifying variables (80% "very good") and making qualitative conclusions (56.66% "very good"), significant challenges emerged in formulating precise algebraic models and relational thinking. Medium and low-ability students frequently exhibited misconceptions, such as treating variables as literal object labels rather than generalized numbers. The study concludes that while basic numeracy is strong, a gap exists in structural understanding. Consequently, it is suggested that mathematics instruction shift from procedural rote learning toward strengthening "structural sense" through diverse contextual modeling to help students transition from symbolic identification to complex relational formulation across all ability levels.

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ABSTRACT

Penelitian ini mengeksplorasi kemampuan numerasi dan pemahaman konseptual siswa mengenai Sistem Persamaan Linear Dua Variabel (SPLDV). Dengan menggunakan metode deskriptif kualitatif, studi ini melibatkan 30 siswa Kelas VIII-C di SMP Negeri 1 Kasihan. Data dikumpulkan melalui tes tervalidasi yang terdiri dari lima soal esai yang dirancang untuk mengukur empat indikator: identifikasi variabel, penyusunan persamaan, penentuan nilai variabel, dan pengambilan keputusan kontekstual. Hasil penelitian menunjukkan bahwa 60% siswa memiliki kemampuan tinggi, 33,33% kemampuan sedang, dan 6,66% kemampuan rendah. Meskipun siswa unggul dalam mengidentifikasi variabel (80% "sangat baik") dan membuat kesimpulan kualitatif (56,66% "sangat baik"), tantangan signifikan muncul dalam merumuskan model aljabar yang presisi dan berpikir relasional. Siswa berkemampuan sedang dan rendah sering kali menunjukkan miskonsepsi, seperti menganggap variabel sebagai label objek literal, bukan sebagai bilangan yang digeneralisasi. Studi ini menyimpulkan bahwa meskipun numerasi dasar sudah kuat, masih terdapat kesenjangan dalam pemahaman struktural. Oleh karena itu, disarankan agar pembelajaran matematika beralih dari sekadar hafalan prosedural menuju penguatan "pemahaman struktural" melalui pemodelan kontekstual yang beragam untuk membantu siswa bertransisi dari identifikasi simbolik menuju perumusan relasional yang

kompleks di semua tingkat kemampuan.

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INTRODUCTION

Mathematics serves as the foundational discipline for modern science and technology, making numeracy a fundamental competency that every student must possess. Numeracy literacy is not merely confined to procedural arithmetic skills; it encompasses the broader capacity to apply mathematical symbols and concepts to solve practical problems in daily life (OECD, 2023). Within the context of Indonesia's *Kurikulum Merdeka*, the reinforcement of numeracy is designed to enable students to reason critically and systematically (Tarso et al., 2025; Wibowo et al., 2025). However, empirical evidence suggests that students' numeracy mastery is often restricted to technical levels lacking deep conceptual understanding (Reyna & Brainerd, 2023). Consequently, when faced with complex real-world scenarios, students frequently encounter obstacles in transforming contextual information into accurate mathematical models (Hatmoko et al., 2024; Rochmat et al., 2025).

In the junior high school mathematics curriculum, the System of Linear Equations in Two Variables (SLETV) stands out for its high relevance to everyday life. SLETV requires robust abstraction skills, as it involves identifying relationships between variables within a contextual problem (Anton & Rorres, 2013). According to Strang (2016) and (Siswanto et al., 2025), an understanding of variables is the primary gateway to formal algebra. Students are expected not only to recognize variables as symbols but also to comprehend their function as quantities representing specific values within a functional relationship (Astiwi & Siswanto, 2024; Syah et al., 2025). Problems arise when students view variables merely as object labels (e.g., x for oranges and y for apples) rather than generalized numerical representations, ultimately triggering misconceptions during equation formulation.

Cognitive gaps often become apparent when students transition from variable identification to the formulation or modeling indicators (Saputra et al., 2025; Ziatdinov & Valles, 2022). Generally, many students demonstrate adequate foundational numeracy in recognizing known data or variables from a problem (Limori et al., 2025; Wahyuni et al., 2024). However, this ability is frequently not accompanied by "structural sense" the capacity to perceive mathematical forms as a logical whole and understand the internal relationships between parts of an equation. Teng & Yue (2023) and Novantoro et al. (2025) explain that without structural sense, students tend to treat algebraic operations as rigid procedural rules without grasping the meaning behind symbol manipulation, leading to a high frequency of errors when problem structures deviate slightly from standard examples.

Initial observations at 1 Kasihan State Junior High School support the suspected discrepancy between technical mastery and relational understanding in SLETV. Although most students could identify variables from word problems with high success rates, they faced significant difficulties when required to establish correlations between these variables in the form of precise linear equations. This phenomenon indicates that students may "know what a variable is" but do not "know how a variable works" within a mathematical system. Firmansyah & Rais (2023) and Harahap et al. (2025) notes that weaknesses in relational thinking constitute a major barrier to achieving expected mathematical literacy, as students fail to see equations as representations of balanced relationships between quantities.

Furthermore, students' difficulties in determining variable values and making decisions based on contextual problems reflect a lack of Higher Order Thinking Skills (HOTS). Robust numeracy should enable students to not only find a final answer but also provide interpretation and justification for their solutions. Wantoro et al. (2025) emphasize that success in algebraic problem-solving depends heavily on a student's mental representation of the problem structure. If this mental representation is flawed for instance, due to the misconception of variables as literal labels then the decisions made based on those calculations will likely be illogical or irrelevant to the original context (Astiwi et al., 2024; Siswanto, 2026).

Given this urgency, this research is imperative to deeply dissect the intersection of the gap between foundational numeracy and structural understanding. Understanding how students of varying ability levels (high, medium, and low) process contextual SLETV information will provide crucial insights for educators in designing more effective learning strategies. The focus of this study extends beyond mapping learning outcomes to include a qualitative analysis of student thought processes. By strengthening structural sense through diverse contextual modeling, it is expected that students will become not only procedurally competent but also logically resilient, meeting the future numeracy challenges set by the National Council of Teachers of Mathematics (NCTM) (2000) standards.

METHOD

This research employs a descriptive qualitative method aimed at analyzing the numeracy skills and conceptual understanding of students in solving Linear Equations in Two Variables (LETV). The study was conducted at 1 Kasihan State Junior High School, involving 30 students from Class VIII-C as research subjects. The primary data collection instrument consisted of a validated test featuring 5 essay questions, designed to measure four specific indicators: identifying variables, constructing linear equations, determining variable values, and making decisions based on contextual problems. This approach allows for a detailed exploration of students' mathematical reasoning and the identification of common misconceptions across different ability levels (Hakim, 2026; Siswanto & Astiwi, 2025).

Data analysis was performed by categorizing students into high, medium, and low-ability groups based on their test scores, followed by a qualitative assessment of their answer sheets (Kulimbang et al., 2026). The researchers calculated the percentage of understanding for each indicator to provide a quantitative overview, which was then triangulated with a content analysis of student work (Naufal et al., 2025). This process involved identifying patterns in how students from different categories approached the material, such as their ability to translate real-world contexts into symbolic math or their struggles with formal notation. By synthesizing these numerical categorizations with specific examples of student errors and successes, the study provides a comprehensive look at the structural sense and relational thinking of the participants.

RESULTS

This research was conducted at 1 Kasihan State Junior High School, with the research subjects being 30 students of Class VIII-C. After the research instruments were validated, a test consisting of 5 essay questions was administered to the Class VIII-C students. The questions covered four indicators based on three aspects of numeracy skills, namely: (1) students' ability to identify variables from the given contextual problem, (2) students' ability to construct linear equations in two variables based on the contextual problem, (3) students' ability to determine the values of x and y from the given problem, and (4) students' ability to make decisions based on the contextual problem involving Linear Equations in Two Variables. Based on the test results, the categorization was carried out as follows

Table 1. Results of Student Group Categorization

Category	**Criteria**	**Number of Students**	**Persentage**
High	≥ 80	16	60%
Medium	$60 \leq x < 80$	11	33,33%
Low	< 60	3	6,66%

Based on table 1, there are 16 students (60%) in the high ability category, 11 students (33.33%) in the medium ability category, and 3 students (6.66%) in the low ability category. The analysis of students' understanding of the Linear Equations in Two Variables material was conducted based on four indicators of conceptual understanding of Linear Equations in Two Variables, and the percentage results of students' understanding are presented in table 2 to provide a clearer overview.

Table 2. Results of analysis based on four question indicators

Indicator	Very Understand	Understand	Fair Understanding	Poor Understanding	Very Poor Understanding
1	80	10	10	-	-
2	-	83,33	13,33	3,33	3,33
3	26,66	46,66	3,33	20	3,33
4	56,66	11, 66	10	13,33	3,33

Analysis of the first two indicators reveals that students possess a strong foundational grasp of identifying variables, with a significant 80% achieving the "very good understanding" category. However, this proficiency slightly diminishes when students are tasked with formulating linear equations. While a majority (83.33%) maintained a "good" level of understanding in this area, the complete absence of students in the "very good" category suggests that translating contextual problems into formal algebraic structures remains a notable challenge. Although the overall performance is positive, these figures highlight a specific gap in the students' ability to construct precise mathematical models from given information.

Regarding the final two indicators, the data shows a diverse range of competence in solving equations and drawing conclusions. In determining the values of x and y, nearly half of the students (46.66%) demonstrated a "good understanding," yet a substantial 20% struggled significantly, falling into the "poor" category. Conversely, students showed stronger performance in the fourth indicator, where 56.66% were able to make very good decisions or conclusions based on their calculations. Collectively, these results indicate that while the majority of the class can effectively navigate the logic of linear equations, targeted intervention is still required for a minority of students who struggle with the technical execution and analytical finality of these problems. Next, the analysis of students' answer sheets on solving problems related to linear equations in two variables is as follows:

1. Analysis of the Work of High-Ability Students (HA)

Determining Variables from Contextual Problems

Question number 1b reads: "The school cooperative sells various kinds of stationery. Restu bought 3 type-x and highlighters with a total cost of Rp. 28,500. Determine the variables of the contextual problem." In the first indicator for question number 1a, the description of the students' abilities from the high category group shows a good understanding in determining the variables of the given contextual problem. Students are able to identify variables correctly, according to the context of the question, and provide appropriate explanations to support their answers.

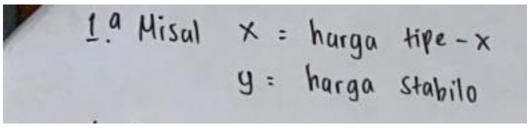

Figure 1. Answer number 1a HA

In question 1a, students are expected to identify the variables from the given contextual problem. One of the answers from a student in the high-ability group (HA) shows that the student successfully determined the variables correctly, representing the price of type-x as the variable xx and the price of the highlighter as the variable y, as shown in Figure 1. Based on the analysis of the answer sheet, it can be concluded that students in the high-ability group (HA) have a good understanding of how to determine the variables from the given contextual problem.

Formulating a Linear Equation in Two Variables

Question 2 asks: "At the school cooperative, various stationery items are sold. Restu bought 3 type-x pens and a highlighter with a total cost of Rp. 28,500. Create a linear equation in two variables based on the information provided in the contextual problem".

For the second indicator in question 1b, the description of the high-ability students' skills shows that they were able to correctly formulate the linear equation in two variables based on the given information. The students could process the data from the contextual problem and formulate the equation according to the correct steps, reflecting a strong understanding of the concept of linear equations in two variables.

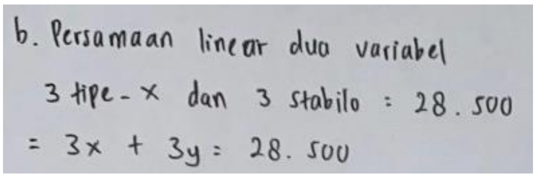

Figure 2. Answer number 1b HA

In question number 1b, students are expected to be able to create or compile two-variable linear equations based on information obtained from contextual problems. The following is one of the student's answers that meets the indicator. In the answer, it can be seen that students have been able to compile two-variable linear equations correctly, the first thing students do in this high group is write down what is known and then change it into a two-variable linear equation. Based on the answer sheet, it can be said that students have a good understanding of the context of the question and can clearly identify the relationship between variables, so that they can compile two-variable linear equations correctly.

Determining the Values of x and y

Question number 3d: "If the price of one adult ticket is Rp. 5,000 more expensive than the price of one child ticket, create a two-variable linear equation that describes the relationship between the price of an adult ticket and a child ticket". The following is a description of the abilities of high group students in the third indicator for question number 3d.

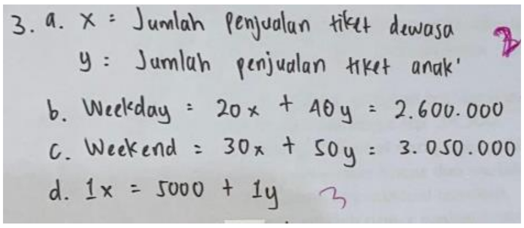

Figure 3. Answer number 3d HA

In question 3d, students are expected to determine the values of x and y. Below is one of the student answers that meets this indicator. It can be seen that the student immediately answered with the equation $1x = 2.000 + 1y$, where in question 3a, it was assumed that x represents the number of adult ticket sales and y represents the number of children's ticket sales. This answer shows that the student has a very good understanding of how to relate the two variables in the form of a simple linear equation. They are able to accurately depict the relationship between adult ticket prices and children's ticket prices, although the notation used is somewhat imprecise.

Making Decisions/Conclusions from the Linear Equation Problem

Here is the description of the high-ability group students' skills for the fourth indicator in question 4:

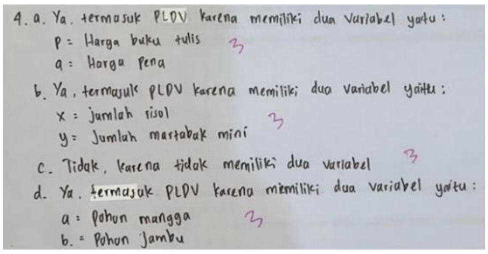

Figure 5. Answer number 4 HA

In figure 5, students are expected to make decisions or conclusions from the contextual problem. Below is one of the student answers that meets this indicator. This high-ability (HA) student is able to easily identify which are linear equations in two variables and which are not, by identifying the known information and making appropriate assumptions. Additionally, this student is also able to provide a clear explanation of their conclusions.

2. Analysis of Student Work in the Medium Ability Group (MA)

Determining Variables from Contextual Problems

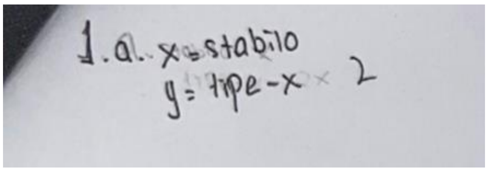

Figure 6. Answer Number 1a MA

Figure 6 represents one of the answers from a student in the medium ability group. The answer sheet shows that the student in the medium group is able to correctly formulate a linear equation in two variables. This indicates that students in the medium ability group (MA) have understood how to identify variables from the given contextual problem.

Formulating Linear Equations in Two Variables

Below is the description of the student's ability in the medium ability group for the second indicator in question number 1b.

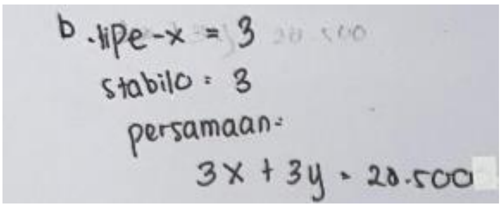

Figure 7. Answer Number 1b MA

In the second indicator, students in the medium ability group showed results identical to those of students in the high ability group. They were able to formulate the linear equation in two variables accurately and correctly, without significant difficulties. Although some students in the medium ability group had not previously identified the variables explicitly, in this indicator, they were able to effectively transform the contextual problem into an appropriate linear equation in two variables.

Determining the Values of x and y

Below is the description of the student's ability in the medium ability group for the third indicator in question number 3d.

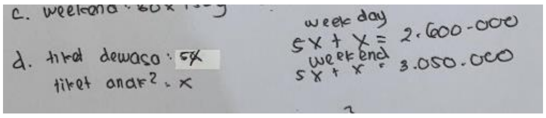

Figure 8. Answer Number 3d MA

In the answer sheet of the medium ability group for question number 3d, it can be observed that the students in this group were not able to meet the third indicator, which is determining the values of x and y. This is demonstrated by errors in variable assignment and difficulty in depicting the relationship between the price of adult tickets and children's tickets.

Making Decisions/Conclusions from the Linear Equation Problem

The following is a description of the abilities of students in the medium group on the fourth indicator for question number 3d.

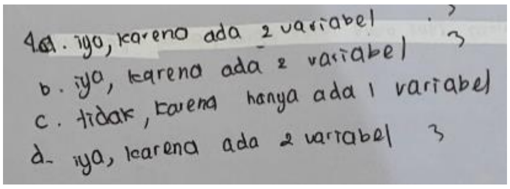

Figure 9. Answer Number 4 MA

In the fourth indicator, the students in the medium ability group were able to meet the requirement. Based on the answer sheet, it is evident that these students could correctly identify which equations were linear equations in two variables from the four contextual problems provided. They were also able to provide reasons or conclusions to justify their decisions, although they did not need to write down the variable identification as students in the high ability group did.

3. Analysis of Student Work in the Low Ability Group (LA)

Determining Variables from the Contextual Problem

The following is a description of the low ability group students' skills for indicator four in question number 1a.

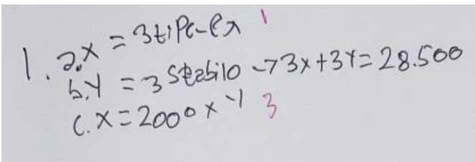

Figure 10. Answer Number 1a LA

Based on the answer sheet of the low ability group, it can be seen that the students demonstrate a correct understanding in selecting variables; however, their way of writing the answer is still incorrect, reflecting a misconception. For example, the student wrote an answer like "x = 3 Tipe-x," where although the variable x and "tipex" are correct, the answer is not written in the correct format and only identifies one variable. This indicates that the low ability group students have not yet mastered how to write variable assumptions in the correct format and have not been able to identify all relevant variables in the contextual problem.

Creating a Linear Equation in Two Variables

The following is a description of the low ability group students' skills for indicator four in question number 1b.

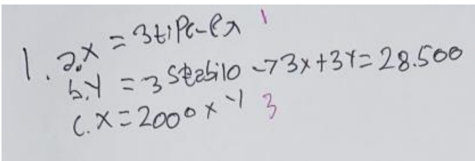

Figure 11. Answer Number 1b LA

Figure 11 is one of the answers from the low group students. On the answer sheet, it can be seen that the low group students showed the ability to create two-variable linear equations correctly. This shows that students in the low group already understand how to determine variables from contextual problems.

Determining the values of x and y

The following is a description of the abilities of low group students on the fourth indicator for question number 3d.

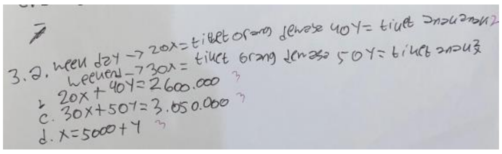

Figure 12. Answer Number 3d LA

Based on the low group answer sheet for number 3d, it can be seen that students immediately answered with the equation $x = 2{,}000 + y$, where in number 3a it is assumed that x is the number of adult ticket sales and y is the number of children's ticket sales, although in the example there is a conceptual error, students in the low group can correctly answer number 3d. this shows that students in the low group have a fairly good understanding of the third indicator.

Determining Decisions/ Conclusions From the Question Linear Equation in Two Variables

The following is a description of the abilities of low group students on the fourth indicator for question number 4.

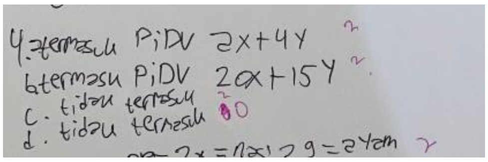

Figure 13. Answer Number 4 LA

Figure 13 is one of the answers of the low group students. Based on the answer sheet, it can be seen that the low group students have not fully understood what is meant by a linear equation of two variables, so they have difficulty in determining which is a Linear Equation in Two Variables and which is not from the contextual questions given. In addition, students also do not provide an explanation regarding the conclusions drawn regarding whether the contextual problem given is included in the category of Linear Equation in Two Variables or not.

DISCUSSIONS

The results of this study indicate that a majority of students (60%) possess a high level of ability in solving contextual LETV problems. This high performance is most evident in the first indicator, where 80% of students demonstrated a "very good understanding" of identifying variables. This success suggests that most students have crossed the initial hurdle of mathematical abstraction translating real-world objects, such as stationery, into symbolic representations (x and y). This aligns with research by Kuncoro et al. (2023) and Dede et al. (2021), which posits that the ability to identify variables is a fundamental prerequisite for; without it, students cannot proceed to higher-level algebraic operations.

However, a shift in proficiency occurs when students are required to formulate equations (Indicator 2). While 83.33% fall into the "good understanding" category, there is a notable absence of students in the "very good" category. The data reveals that while high-ability (HA) and medium-ability (MA) students can construct equations accurately, low-ability (LA) students often struggle with formal notation. For instance, an LA student representing a variable as "$x = 3$ (Tipe-x)" indicates a persistent literal symbol misconception. As noted by Ngwabe & Felix (2020) and Tillema & Burch (2022), students often treat variables as shorthand for objects rather than representing generalized numbers, a conceptual barrier that hinders the creation of accurate algebraic models.

The third indicator, determining the relationship between x and y, proved to be the most challenging for the medium-ability group. While HA students successfully related ticket prices, MA students exhibited errors in variable assignment and struggled to depict the mathematical relationship between the two entities. This specific difficulty suggests a weakness in "relational thinking." According to Alam et al. (2025) and Siswanto et al. (2026), students often focus on computational procedures rather than the underlying structural relationships in an equation. The inability of MA students to meet this indicator highlights a gap between being able to follow a template (Formulation) and understanding the logic of the relationship (Relational Analysis).

Interestingly, the fourth indicator making decisions or conclusions showed relatively strong results, with 56.66% of students categorized as having a "very good understanding." HA and MA students were generally capable of identifying which contextual problems constituted an LETV and providing justifications. This suggests that students' qualitative reasoning the ability to categorize and explain may be more developed than their technical algebraic manipulation. This finding mirrors the work of Aprilia et al. (2025), Efendi et al. (2025) and Fitriana et al. (2025), who argued that students often develop conceptual "big picture" ideas before they master the intricate syntax of mathematical representation.

The performance of the low-ability (LA) group provides a critical insight into the nature of mathematical misconceptions. Although some LA students could identify the correct equation by chance or intuition (as seen in the ticket price problem), they failed significantly in the fourth indicator, where they could not distinguish between LETV and non-LETV problems. Their inability to provide explanations suggests a lack of "structural sense." Research by Kintoko & Siswanto (2024), Maba et al. (2025) and Ramadhani et al. (2023) suggests that students with low structural sense view equations as strings of symbols to be manipulated rather than meaningful mathematical objects, leading to inconsistent performance across different problem contexts.

In conclusion, while the overall numeracy level at 1 Kasihan State Junior High School is positive, the transition from identifying variables to understanding the deep relational structure of equations remains a hurdle for medium and low-ability students. The discrepancy between students' ability to "do" the math (Indicator 1 and 2) and "explain" the logic (Indicator 3 and 4) suggests that instructional focus should shift from procedural fluency to structural understanding. This is consistent with (Filahanasari, 2020; NCTM, 2000), which emphasize that true mathematical competence requires a balance of conceptual understanding, procedural skill, and the ability to formulate and justify mathematical arguments.

CONCLUSION

The research concludes that while students at 1 Kasihan State Junior High School generally demonstrate strong numeracy skills in identifying variables (80% very good understanding) and making qualitative decisions (56.66% very good understanding), significant gaps remain in their structural and relational understanding of Linear Equations in Two Variables (LETV). High-ability students consistently perform well across all indicators, but medium and low-ability students frequently struggle with formal algebraic notation and the underlying logic of variable relationships, often falling into misconceptions where variables are treated as object labels rather than generalized numbers. Consequently, it is suggested that mathematics teachers shift their instructional focus from rote procedural fluency toward strengthening "structural sense" and relational thinking through more diverse contextual modeling exercises. Future learning interventions should specifically address the transition from symbolic identification to the formulation of complex relationships to ensure that students across all ability levels can move beyond "doing" the math to truly "understanding" its logical framework.

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