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# The identification of misconceptions in visual learners based on the certainty of response index (CRI) in solving numeracy problems in algebra

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**Abstract**
This study aims to identify and analyze the misconceptions encountered by students with a visual learning style in solving algebraic numeracy problems using the Certainty of Response Index (CRI) method. The research was conducted with eighth-grade students at SMPN 4 Jember who had previously studied equations and inequalities. A qualitative descriptive approach was employed, with data collected through questionnaires, tests, and interviews. To ensure data validity, member checks were conducted. The findings reveal three distinct types of misconceptions: theoretical, correlational, and classificational. Students with a visual learning style exhibited theoretical misconceptions, including misunderstandings of variable concepts and PtLSV (*Pertidaksamaan Linear Satu Variabel* - One-variable Linear Inequality) framework, errors in algebraic operation principles, and flawed reasoning when responding to problems. Additionally, correlational misconceptions were identified, such as difficulties in translating given information into mathematical expressions and errors in representing concepts across different mathematical formats. These misconceptions primarily stem from students' incomplete or inaccurate prior knowledge, limited conceptual understanding, and associative thinking patterns. To mitigate these issues, educators are encouraged to assess students' initial comprehension through diagnostic testing, enabling early identification and correction of misconceptions. Addressing these misunderstandings at an early stage can prevent further cognitive obstacles when students engage with more complex mathematical concepts.

**Keywords:** Certainty of response index, Misconception, Visual learning styles

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## Introduction

Education in the era of globalization must ensure that students acquire 21st-century life skills, one of which can be achieved through numeracy literacy activities (Pusat Asesmen dan Pembelajaran, 2021). Education in the era of globalization must ensure that students acquire 21st-century life skills, one of which can be achieved through numeracy literacy activities (Pusmendik, 2023). This finding suggests that a significant number of junior high school students in Indonesia have yet to meet the expected numeracy competency standards. If students struggle with or fail to master numeracy problems, their ability to solve real-life problems efficiently may be hindered (Irfan et al., 2023). This is because numeracy refers to an individual's ability to apply mathematical knowledge in explaining phenomena, solving problems, and making decisions in everyday life (Pusat Asesmen dan Pembelajaran, 2020). Therefore, it is crucial to implement various strategies to enhance students' numeracy skills, such as fostering familiarity with numeracy-based questions. These types of questions can be found in the Minimum Competency Assessment (AKM) (Pusat Asesmen dan Pembelajaran, 2020).

One of the numeracy content areas in the Minimum Competency Assessment (AKM) is algebra. Algebra is a fundamental component of mathematics that encompasses numerous concepts, making it a key subject in the secondary mathematics curriculum (Sari & Afriansyah, 2020). It is also considered an essential yet challenging and abstract area of mathematics (Rahayu et al., 2022). Equations and inequalities are among the topics covered in algebra. Rohimah (2017) states that when solving problems related to linear equations and inequalities, students may make errors due to the cognitive leap from arithmetic thinking to algebraic reasoning, limited contextual understanding, and difficulties in constructing the concepts of equations and inequalities. If the conceptual formation process is not well-developed, students may experience misconceptions. Various misconceptions can lead to errors in problem-solving, ultimately affecting students' academic performance (Isyam et al., 2019). Therefore, it is essential for students to develop a correct and precise understanding of mathematical concepts to anticipate and effectively address mathematical challenges in the future (Ramadhan et al., 2017).

One approach to identifying misconceptions among students is through diagnostic testing and the use of the Certainty of Response Index (CRI) technique (Isyam et al., 2019). CRI is a method for measuring an individual's confidence in answering given questions, presented in the form of a scale. Students who respond to questions with a low CRI confidence scale indicate uncertainty in their conceptual understanding and a high likelihood of guessing. Conversely, students who provide responses with a high CRI confidence scale demonstrate strong conceptual certainty and confidence in their answers (Tayubi, 2005). The efficiency of CRI in distinguishing between students who understand the concept, those who do not, and those experiencing misconceptions is the primary reason researchers have chosen to employ this technique in the present study.

Dewanti ( as cited in Ayuni & Arif, 2023) states that students' misconceptions arise from two factors: internal factors and external factors. One internal factor influencing misconceptions is learning style. Guswanto, Susanto, & Trapsilasiwi, D., (2018) define learning style as an individual's approach to acquiring and processing information from their environment. A student's understanding of mathematical concepts can be effectively achieved when aligned with their preferred learning style (Ramadhan et al., 2017). Deporter & Hernacki classify learning styles into three types: visual, auditory, and kinesthetic (Bire et al., 2019). Nasution explains that students with a visual learning style tend to quickly grasp information presented in visual form (Ayuni & Arif, 2023). However, during the learning process, students often employ thinking patterns that do not align with scientific or intuitive reasoning, making them more susceptible to misconceptions (Ayuni & Arif, 2023). This indicates that although visually oriented students exhibit certain characteristic tendencies, they are still prone to errors in absorbing information or in establishing connections between concepts.

The relationship between visual learning style and numeracy problems in algebra content can be observed in how visually oriented students process information presented in the form of symbols, graphs, or other visual representations. Since algebra often involves mathematical modeling and abstraction, students with a visual learning style may struggle if the information does not align with their learning preferences. For instance, visually oriented students tend to associate concepts based on patterns or observable relationships, which can lead to correlational misconceptions if algebraic concepts are not properly understood (Sholehah et al. (2021). Research by Ayuni & Arif (2023) indicates that students with a visual learning style exhibit the highest rate of misconceptions compared to other learning styles, particularly in fact-based misconceptions. Thus, the misconceptions experienced by visually oriented students can significantly impact their ability to solve algebraic numeracy problems, as they often misinterpret abstract mathematical information—especially in the subdomain of equations and inequalities. Given this reality, the researchers aim to focus their study on visually oriented students to describe how their misconceptions manifest in solving algebraic numeracy problems within the subdomain of equations and inequalities. The findings of this study can serve as a reference for improving students' conceptual understanding in this subject area.

## Methods

This study employs a qualitative research method analyzed descriptively. The primary objective is to describe the misconceptions experienced by visually oriented students in solving algebraic numeracy problems. The research was conducted with eighth-grade students (Class VIII A) at SMPN 4 Jember, considering that these students have already been introduced to and are familiar with numeracy problems. Data collection took place during the even semester of the 2023/2024 academic year.

The main research instrument in this study is the researcher, while supporting instruments include a learning style questionnaire, numeracy test accompanied by a CRI (Certainty of Response Index) scale, and an interview guide. Data were collected using questionnaire, test, and interview methods. The selection of research subjects was carried out using purposive sampling, with participants drawn from Class VIII A, consisting of 31 students. These students were given a learning style questionnaire and a numeracy test accompanied by a CRI scale.

The learning style questionnaire consists of 14 multiple-choice statements, adapted from a developmental study conducted by Sugianto (2021). This questionnaire is used to categorize students based on their learning styles, namely visual, auditory, and kinesthetic. The analysis of the learning style questionnaire is conducted by calculating students' responses to each question. Each question provides three answer options: a, b, and c. If a student predominantly selects option a, it indicates a visual learning style. If a student predominantly selects option b, it indicates an auditory learning style. If a student predominantly selects option c, it indicates a kinesthetic learning style (Sugianto, 2021).

The algebraic numeracy test consists of three multiple-choice questions, each accompanied by step-by-step solutions and a Certainty of Response Index (CRI) scale. The numeracy test with the CRI scale is used to identify students who understand the concept, those who do not, and those experiencing misconceptions. CRI is a technique for measuring an individual's confidence level in answering each given question (Hasan et al., 1999). The CRI scale and its criteria are presented in Table 1.

**Table 1.** CRI Scale and Criteria

| CRI | Criteria | Description |
|---|---|---|
| 0 | Totally guessed answer | If the answer is 100% guessed |
| 1 | Mostly guessed | If the answer contains 75%-99% guessing |
| 2 | Not sure | If the answer contains 50%-74% guessing |
| 3 | Somewhat sure | If the answer contains 25%-49% guessing |
| 4 | Nearly certain | If the answer contains 1%-24% guessing |
| 5 | Completely certain | If the answer contains 0% guessing (fully confident) |

Source: Tayubi (2005)

The analysis of CRI questionnaire results is conducted by examining students' answers alongside their solution steps and CRI scores, referring to Table 2, which outlines the criteria for distinguishing students who understand the concept, do not understand the concept, or experience misconceptions on an individual basis.

**Table 2.** CRI Criteria for Individual Assessment

| Answer | Solution Steps | CRI Score | Category |
|---|---|---|---|
| Correct | Correct | > 2,5 | Understands the concept |
| Correct | Correct | < 2,5 | Understands the concept but is uncertain about the answer |
| Correct | Incorrect | > 2,5 | Misconception |
| Correct | Incorrect | < 2,5 | Does not understand the concept |
| Incorrect | Correct | > 2,5 | Misconception |
| Incorrect | Correct | < 2,5 | Does not understand the concept |
| Incorrect | Incorrect | > 2,5 | Misconception |
| Incorrect | Incorrect | < 2,5 | Does not understand the concept |

Source: Modified from Hakim et al. (2012)

Based on Table 2, this study defines students experiencing misconceptions as those who report a high confidence level (>2.5 on the CRI scale) while providing answers that fall into one of the following categories: 1) Correct answer but incorrect solution steps; 2) - Incorrect answer but correct solution steps; 3) Both answer and solution steps are incorrect

The data from the learning style questionnaire and numeracy test accompanied by the CRI questionnaire were analyzed to select research subjects. The students chosen as research subjects were those with a visual learning style, based on the following criteria: 1) Identified as experiencing misconceptions in every test question, 2) Achieved the highest learning style score. The analysis of the learning style questionnaire revealed that out of 31 students, 18 were identified as having a visual learning style. Among these 18 students, CRI analysis indicated that 7 students experienced misconceptions, and 3 of them met the criteria as research subjects, with their details provided as Table 3.

**Table 3.** Research Subjects

| Subject | Learning style | | Description | | |
|---|---|---|---|---|---|
| | Type | Score | Question 1 | Question 2 | Question 3 |
| SV1 | Visual | 9 | Understand the concept | Understand the concept | Misconception |
| SV2 | Visual | 9 | Understand the concept | Misconception | - |
| SV3 | Visual | 7 | Misconception | Understand the concept | - |
| Note: | | | - = Did not work on the question | | |

The three research subjects are eighth-grade students (Class VIIIA) in the even semester of the 2023/2024 academic year who have studied equations and inequalities, including PLSV (*Persamaan Linear Satu Variabel* - Linear Equation in One Variable), PtLSV (*Pertidaksamaan Linear Satu Variabel* - Linear Inequality in One Variable), PLDV (*Persamaan Linear Dua Variabel* - Linear Equation in Two Variables), and SPLDV (*Sistem Persamaan Linear Dua Variabel* - System of Linear Equations in Two Variables). SV1 has the characteristic of easily remembering information by visualizing it. Their learning style involves following image-based instructions and understanding lessons more effectively through visual aids. SV2 shares similar characteristics with SV1, but SV2 also prefers taking notes. SV3 enjoys taking notes, easily remembers what they see, and is not easily distracted by noise while studying.

The study proceeded with interviews with the research subjects to confirm the types of misconceptions they experienced. The interviews were conducted in a semi-structured format. Following this, the test and interview data were analyzed. The test data analysis involved: Summarizing the test results, Reviewing the collected data, Reducing irrelevant data, Analyzing misconceptions, Drawing conclusions.

The interview data analysis was conducted by listening to recorded interviews, then reducing the data by selecting relevant information and eliminating data that did not align with the research objectives. After analysis, the data were presented, validated through member checks, and final conclusions were drawn. The misconceptions observed in this study were categorized into three types: Theoretical misconceptions, Correlational misconceptions, Classificational misconceptions.

The indicators used in this study were adapted from those developed by Sholehah et al. (2021). To facilitate understanding, the indicators and descriptors are presented in Table 4.

**Table 4.** Indicators and Descriptors of Misconceptions

| Types of Misconception | Indicator | Descriptor | Code |
|---|---|---|---|
| Theoretical Misconception | Errors in understanding facts or events within an organized system | Misunderstanding the concepts of coefficients, variables, constants, terms, equations, inequalities, and solution sets. | 1a |
| | | Errors in understanding mathematical properties or principles | 1b |
| | | Errors in reasoning when answering questions (Ainiyah, 2016). | 1c |
| Correlational Misconception | Errors in understanding interrelated concepts and formula explanations | Errors in converting known information into mathematical form. | 2a |
| | | Errors in presenting concepts in various mathematical representations (graphs, mathematical models, or other forms). | 2b |
| | | Errors in explaining the relationship between the formula used and the problem in the question (Ainiyah, 2016) | 2c |
| Classificational Misconception | Errors in classifying mathematical terms | Errors in identifying coefficients, variables, constants, and terms. | 3a |
| | | Errors in distinguishing between examples and non-examples of equations and inequalities. | 3b |

## Result

The following presents a detailed analysis of misconceptions among visually oriented students.

### Description of SV3's Misconception in Question 1

For Question 1, SV3 provided an incorrect answer, used incorrect solution steps, and rated their CRI confidence level as "Sure" (3). This indicates that SV3 experienced a misconception. Figure 1 is the analysis of SV3's test results and interview responses in solving Question 1.

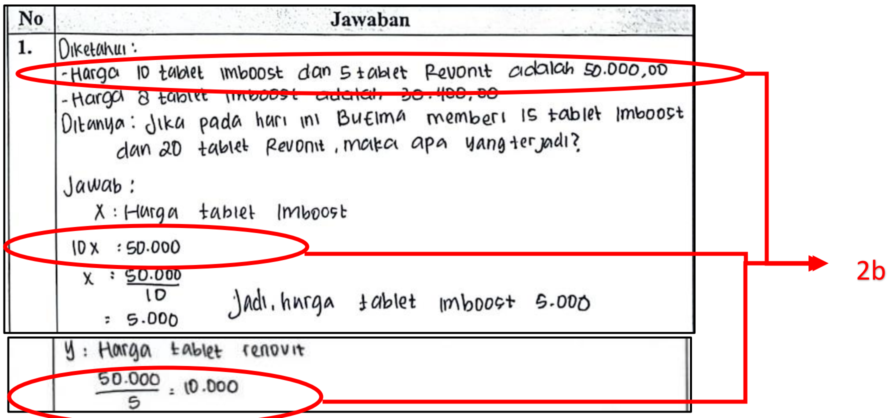


**Figure 1.** Excerpt of SV3's Answer to Question 1

Translation:

**Given:**

- The price of 10 Imboost tablets and 5 Revonit tablets is 50,000
- The price of 8 Imboost tablets is 30,400

**Asked:**

If Mrs. Elma buys 15 Imboost tablets and 20 Revonit tablets today, what will happen?
Solution:
Let x be the price of one Imboost tablet
[10x = 50,000]
[x = 50,000/10 = 5000]
So, the price of one Imboost tablet is 5,000
Let y be the price of one Revonit tablet
[y = 50,000/5 = 10,000]
So, the price of one Revonit tablet is 10,000

Figure 1 with code 2b indicates that SV3 recognizes that the price of 10 Imboost tablets and 5 Renovit tablets is Rp50,000.00. However, SV3 made an error in constructing the mathematical model, where they wrote 10x = 50,000 to determine the price per Imboost tablet and y = 50,000 / 5 to determine the price per Renovit tablet. Using the same assumptions, the correct mathematical model should be: [ 10x + 5y = 50,000 ].

This error suggests that SV3 misrepresented the concept of PLDV by incorrectly converting the problem into PLSV. Additionally, SV3 provided reasoning for the mathematical model they created. Below is an excerpt from the researcher's interview with SV3, which further supports this analysis.

| | |
|---|---|
| *Researcher* | *: Can SV3 formulate the problem into a mathematical model?* |
| *SV3* | *: So, initially, the equation for purchasing Imboost is created. Let x represent the price of an Imboost tablet, and the mathematical model is: [ 10x = 50,000 ]. Then, to determine the price of Renovit, let y represent the price of a Renovit tablet, and the mathematical model is: [ 5y = 50,000 ]* |
| *Researcher* | *: Are you confident that the mathematical model you created is correct? Why did you structure the model this way? Isn't the model you created derived from the statement: "The price of 10 Imboost tablets and 5 Renovit tablets is Rp50,000"?* |
| *SV3* | *: Yes, that's correct, because here we are focusing on finding the price of Imboost and Renovit. So, to determine the price of an item from an equation, we simply write the unknown variable equal to the total price.* |
| *Researcher* | *: If that's the case, can you explain the strategy SV3 used to solve this problem?* |
| *SV3* | *: To find the price of Imboost, the equation is:* $10x = 50.000$*, thus* $x = \frac{50.000}{10} = 5.000$*. To find the price of Renovit from the equation* $5y = 50.000$*, thus* $y = \frac{50.000}{10} = 5.000$*. So, the unit price of Imboost is 5,000, and the unit price of Renovit is 10,000.* |

According to the interview, SV3 expressed strong confidence in the mathematical model they created. This further reinforces the identification that SV3 made an error in representing the concept within the mathematical model (2b).

Additionally, SV3 provided reasoning for the mathematical model they constructed. SV3 stated that to find the price of an item from an equation, one simply writes the unknown variable equal to the total price. For example, to determine the price of Imboost per tablet, SV3 formulated the equation as 10x = 50,000, leading to the result x = 5,000.

However, this reasoning is incorrect, because {5,000, 10,000} is not a valid solution for the PLDV as it does not satisfy the equation. Therefore, SV3 exhibited an error in reasoning when answering the question (1d). Based on the analysis of Question 1, SV3 was identified as experiencing both theoretical and correlational misconceptions.

## Description of SV2's Misconception in Question 2

For Question 2, SV2 provided an incorrect answer, used incorrect solution steps, and rated their CRI confidence level as "Almost Certain" (4). This indicates that SV2 experienced a misconception. Below is the analysis of SV2's test results and interview responses in solving Question 2.

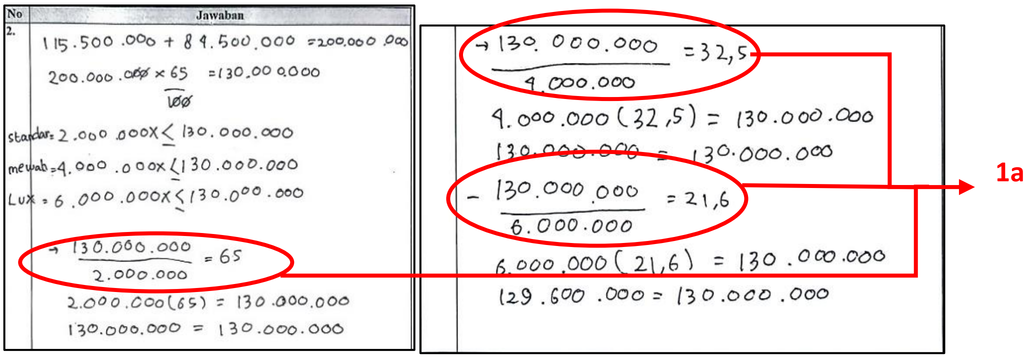

**Figure 2**. SV2's Answer to Question 2

Based on Figure 2, SV2 correctly determined the total balance, identified the maximum cost, and constructed the mathematical model accurately. However, in code 1a, there is a discrepancy in how SV2 solved the mathematical model. During the solution process, SV2 treated the inequality as an equation by changing the inequality sign, indicating a misunderstanding of the concept of inequalities. Additionally, SV2 selected option C, which is incorrect. Since SV2 did not provide a written explanation for their choice, the researcher explored their reasoning through an interview.

The following is an excerpt from the Researcher's Interview with SV2.

*Researcher : What strategy did you use to solve this problem?*

*SV2 : To find the area, I first made my model equal, then, for example, in the standard type, 130,000,000, I divided it by 2,000,000, and I did the same for the others.*

*Researcher : Why did you choose to answer using this strategy?*

*SV2 : Because if I didn't change the inequality sign, I would get confused about how to solve it*

*Researcher : Is there another way to solve this problem?*

*SV2 : No, this is the only method I thought of.*

*Researcher : Why did you select option C as your answer? Was there a reason for choosing it?*

*SV2 : Well, option C states that the building is "not less than 50m²", and based on my calculations for the luxury type, the result was $x \leq 32.5$, so I thought it was a good fit.*

*Researcher : What does "not less than 50m²" mean?*

*SV2 : It means below 50m², and since 32.5m² is below 50m², I chose C.*

According to the interview, SV2 stated that the inequality sign needed to be changed to an equation in order to solve the problem. However, the correct solution should be performed without changing the inequality sign. Thus, SV2 was identified as having a misunderstanding of the concept of PtLSV (1a).

The excerpt from the interview also presents SV2's reasoning for selecting option C, where SV2 interpreted "not less than" as "less than or equal to (≤)". As a result, SV2 understood the statement in option C—"the building area is not less than 50m²"—to mean that the building could have an area below 50m². Since 32.5m² is below 50m², SV2 believed this was consistent with their calculations for the luxury-type house. However, the correct interpretation of the phrase "the building is not less than 50m²" should be that the building has an area of 50m² or more. In other words, "not less than" is equivalent to "greater than or equal to (≥)". Thus, SV2 was identified as having made an error in interpreting mathematical representations. Based on the analysis of Question 2, SV2 was found to have both theoretical and correlational misconceptions.

### Description of SV1's Misconception in Question 3

For Question 3, SV1 selected the correct answer, but used incorrect solution steps, and rated their CRI confidence level as "Almost Certain" (4). This indicates that SV1 experienced a misconception.

Figure 3 is the analysis of SV1's test results and interview responses in solving Question 3.

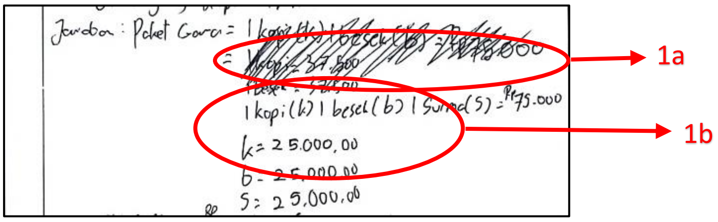


**Figure 3**. Excerpt of SV1's Answer to Question 3

In code 1a, SV1 wrote kopi (k), besek (b), and surma (s). Typically, students use such abbreviations as a habit to simplify words. However, after confirmation through an interview, SV1 clarified that these abbreviations specifically represent coffee, a basket of tape, and dates. Below is the researcher's interview with SV1, which further supports this analysis.

*Researcher : So, does k, b, s represent coffee, a basket of tape, and dates, or are they variables for the prices?*

*SV1 : They are representations for coffee, a basket of tape, and dates.*

This analysis reveals several errors in SV1's understanding of mathematical concepts, particularly in variables, algebraic operations, and problem-solving strategies. In code 1b, the student wrote "k=25,000; b=25,000; s=25,000" as the solution to the mathematical model they had created. SV1 explained the meaning of this notation during an interview. Below is the transcript of the interview between the researcher and the subject.

*Researcher : Is that so? But earlier, there was an assumption for b, k, s—aren't b, k, s different variables?*

*SV1 : Yes, that's correct, but in the gamma package, the coefficients of b, k, s are all 1, so they are the same. That means 1k + 1b + 1s = 75,000. When summed together, the total is 3, so the result is 3kbs = 75,000, which leads to the solution k = 25,000; b = 25,000; s = 25,000.*

Based on the interview excerpt, SV1 stated that they summed the variables k, b, s as k + b + s = 3kbs, leading to the solution k = 25,000; b = 25,000; s = 25,000. This indicates that SV1 made an error in performing algebraic operations. In algebra, addition should only apply to like terms. Therefore, it can be identified that SV1 misunderstood the principles of algebraic operations (1b).

Another mistake made by SV1 was that, although they recognized that question number 3 required the SPLDV concept, they solved it using the PLSV concept, as stated during the interview. The reason for using this concept was also explained in the interview. Below is an excerpt from the researcher's interview with SV1.

| | |
|---|---|
| *Researcher* | *: SV1, can you explain which concepts were used to solve question number 3?* |
| *SV1* | *: SPLDV.* |
| *Researcher* | *: Here, we have k = 25,000, b = 25,000, and s = 25,000. Can you explain that part—how did you arrive at this answer?* |
| *SV1* | *: I looked at three packages, and one of them—the Gamma package—shows the quantity of items individually. So, from the Gamma package, I found the price of 1 coffee, 1 besek tape, and 1 surma by dividing 75,000 by 3. This gave me the price of 1 coffee, 1 besek tape, and 1 surma, each at Rp 25,000.* |
| *Researcher* | *: Then, what is the function of the Alpha package and Beta package in that case?* |
| *SV1* | *: I didn't pay much attention to them because using the Alpha and Gamma packages would make things more complicated—it would require elimination and substitution. Meanwhile, the Gamma package is equivalent to the other packages because this is an equation, so it will have the same solution. That means I can also determine the price of 1 coffee, 1 besek Tape, and 1 Surma from the Gamma package, as it already represents everything.* |

According to the interview, SV1 stated that the three equations presented in the question have the same solution, so the solution can be determined from just one equation. This indicates that SV1 made an error in reasoning when answering the question (1d).

Question number 3 states that the store will give a 10% discount on purchases of at least Rp 300,000.00 per package. However, based on the interview results, SV1 misinterpreted this, believing that the store provides a 10% discount on the total purchase as long as the minimum package purchase is Rp 300,000.00. Below is an excerpt from the researcher's interview with SV1.

| | |
|---|---|
| *Researcher* | *: Look at question number 3! What information did SV1 get from the question?* |
| *SV1* | *: There is a store where the package prices and individual item prices are the same. The details are as follows: Alpha package consists of 5 coffees and 2 besek tapes, priced at Rp 265,000.00. Beta package consists of 4 coffees and 3 besek tapes, priced at Rp 240,000.00. Gamma package consists of 1 coffee, 1 besek tape, and 1 surma, priced at Rp 75,000.00. Additionally, the store offers a 10% discount on the total purchase if the minimum package purchase is Rp 300,000.00.* |

This indicates that SV1 misinterpreted the information. As a result, SV1 made an error in converting the actual information into a mathematical representation, which is evident in Figure 4. In code 2a, it appears that SV1 subtracted 10% of the total purchase as a discount and chose option D, which involved buying "6 Gamma packages" plus 1 packaged coffee and 5 surma individually.

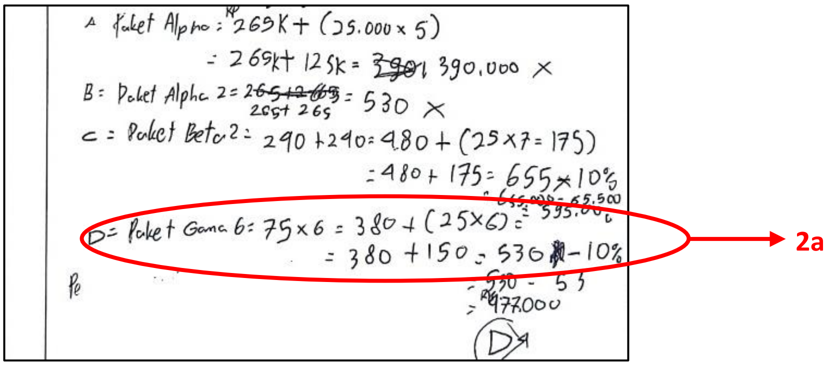


**Figure 4.** Excerpt from SV1's Answer to Question Number 3

SV1 explained the reasoning behind the choice in the following interview.

*Researcher : Next, based on SV1's answer, why did you choose option D?*

*SV1 : Well, after determining the prices, I inserted the known prices into each option: Option A: 265,000 + (25,000 × 5) = 265,000 + 125,000 = 390,000 → No discount applied because the package does not meet the minimum requirement. Option B: 530,000, Option C: (2 × 240,000) + (25,000 × 7) = 480,000 + 175,000 = 655,000, then a 10% discount is applied: 65,500, resulting in 595,000. Option D: (75 × 6) + (25 × 6) = 380,000 + 150,000 = 530,000, then a 10% discount is applied: 53,000, resulting in Rp 477,000. Since option D is closest to Rp 500,000.00, I chose D as the answer.*

Based on the interview results, SV1 stated that option D was chosen because it was closest to the desired total purchase amount of Rp 500,000.00. Therefore, it can be identified that SV1 made an error in converting information into a mathematical representation (2a). Based on the analysis of question number 3, it can be identified that SV1 experienced both theoretical misconceptions and correlational misconceptions.

## Discussion

The results of the test data analysis and interviews indicate that in solving numeracy problems related to algebra content, specifically in the subdomain of equations and inequalities, visual learners experience both theoretical misconceptions and correlational misconceptions. This differs from previous research conducted by Sholehah et al. (2021) which stated that in the topic of lines and angles, visual learners only experienced correlational misconceptions.

The difference in research findings may be due to the different characteristics of the subjects studied. This study focuses on misconceptions in algebra content, whereas the previous study focused on misconceptions in geometry content. Algebra, especially in the subdomain of equations and inequalities, is abstract and contains many concepts (Rahayu et al., 2022; Sari & Afriansyah, 2020). Algebra involves symbols and their manipulation, emphasizes logical reasoning, and develops sequentially (Rangkuti, 2022). In contrast, studying geometry requires visualization skills and spatial abilities (Wiharjo et al., 2016). Although geometry content in the topic of lines and angles is also abstract, learning often involves concrete objects, which can help students understand the concepts more easily (Akhmadan, 2017). Thus, the differences in subject characteristics cause visual learners to face different challenges in each topic. These challenges include how students learn facts or patterns in an organized system, understand relationships between events, observe general principles, and categorize facts or occurrences into structured groups, which are reflected in the types of misconceptions they experience.

The results of the test data analysis and interviews in this study also show that the same type of misconception can lead to different errors. The types of errors students made are outlined as Table 5. Visual learners often experience both theoretical and correlational misconceptions when solving algebraic numeracy problems. Theoretical misconceptions include difficulties in understanding the concept of variables and PtLSV, errors in applying algebraic operation principles, and flawed reasoning in responding to questions. Correlational misconceptions, on the other hand, involve challenges in formulating mathematical problems correctly and presenting concepts using appropriate mathematical representations.

Among these, the most frequent misconceptions found among visual learners are conceptual misunderstandings, errors in reasoning, and difficulties in translating mathematical ideas across different forms of representation. Although visual learners tend to grasp information quickly when it is presented visually (Ayuni & Arif, 2023), they may still struggle to develop deep conceptual understanding if the instructional methods used are not aligned with their learning preferences. As Ramadhan et al. (2017) emphasize, conceptual mastery in mathematics is more effectively achieved when the learning approach matches students' individual learning styles.

In terms of theoretical misconceptions, visual learners tend to misinterpret variables (1a) by treating them as labels rather than abstract symbols. For instance, students inaccurately assigned concrete meanings to variables such as k, b, and s, associating them with coffee, besek tape, and surma, respectively. This misinterpretation often leads to subsequent errors in applying algebraic principles (1b), including the inappropriate combination of addition and multiplication operations. One example of this is the equation $k + b + s = 3kbs$, where students failed to recognize that addition in algebra should be applied only to like terms. Such misconceptions are in line with the findings of Rahayu et al. (2021), who reported that students often conjoin different operations and view variables as mere labels.

Furthermore, visual learners also misconceive the nature of PtLSV (1a), often replacing inequality signs with equal signs. This suggests associative thinking—where one mathematical concept is perceived as always equivalent to another—leading students to believe that solving inequalities is the same as solving equations. Altin et al. (2021) identify this as a common error pattern among students, a view supported by Taqiyuddin et al. (2017) who found that learners frequently ignore inequality symbols and treat inequalities as standard equations.

Another significant theoretical misconception is related to reasoning (1d). Students with a weak conceptual foundation tend to rely solely on their intuition or personal reasoning, resulting in misinterpretation of mathematical problems. As Pratiwi (2018) found, such reasoning-based misconceptions often emerge when students lack a complete understanding of the concept and attempt to construct meaning based only on fragmented knowledge.

**Table 5**. Errors Experienced by Students in Each Type of Misconception

| Code | Descriptor | Student Answers and Errors |
|---|---|---|
| | | **Theoretical Misconceptions** |
| 1a | Errors in understanding the concept of variables | Student's answer: writing variable assumptions: k = coffee, b = *Besek Tape*, s = *Surma* (question 3)<br>Error: The student interprets variables as labels. |
| | Error in understanding the concept of PtLSV | Student's Answer:<br>Standard: $2.000.000x \leq 130.000.000$ (Question 2)<br>$\rightarrow \frac{130.000.000}{2.000.000} = 65$<br>Error: The student changes the inequality sign into an equality sign. |
| 1b | Error in understanding mathematical principles | Student's Answer:<br>During the interview, the student stated that they summed the variables k,b,s as $k + b + s = 3kbs$ (question 3)<br>Error: The student combined the principles of addition and multiplication in algebraic operations. |
| 1d | Error in reasoning used to answer the question | Student's Answer:<br>The student wrote two mathematical models for the price of 10 Imboost tablets and 5 Renovitt tablets, totalling Rp 50,000, as follows:<br>$10x = 50.000$ (to find the price of Imboost per tablet) and $y = \frac{50.000}{5}$ (to find the price of Renovit per tablet) (Question 1).<br>During the interview, the student stated that the value of a variable can be found by creating an equation based on the total available price.<br>Error: The student formed a mathematical model based on their own reasoning.<br>Student's Answer:<br>The student wrote 1 coffee + 1 B*esek* +1 S*urma* = Rp75.000 (Question 3)<br>$k = 25.000\ ; b = 25.000; s = 25.000$<br>The student solved SPLDV using only one equation, ignoring the other two equations.<br>During the interview, the student stated that the three equations presented in the question have the same solution, so the solution can be determined from just one equation.<br>Error: The student treated SPLDV as if it were a PLSV |
| | | **Correlational Misconceptions** |
| 2a | Error in converting information into a mathematical concept | Student's Answer:<br>Error in converting actual information into a mathematical representation (question 3)<br>Error: The student misinterpreted the given information |
| 2b | Error in presenting concepts in various mathematical representations | Student's Answer:<br>The student wrote two mathematical models for the price of 10 Imboost tablets and 5 Renovit tablets, totalling Rp 50,000 as follows:<br>$10x = 50.000$ (to find the price of Imboost per tablet) and $y = \frac{50.000}{5}$ (to find the price of Renovit per tablet) (question 1)<br>Error: The student misrepresented the concept of PLDV as PLSV |
| | Error in interpreting mathematical representations | Student's Answer: The student interpreted "not less than" as "less than or equal to (≤)"(question 2)<br>Error: The student misinterpreted the mathematical representation. |

Correlational misconceptions also emerged in this study. Despite the use of real-world contexts in the numeracy tests, students struggled to convert known information into correct mathematical expressions (2a). Rohimah (2017) attributes this to limited contextual understanding, which may result from a lack of practice in applying mathematical concepts to practical problems. Additionally, visual learners had difficulty expressing concepts in multiple mathematical formats (2b). For instance, some students mistakenly represented a *Persamaan Linear Dua Variabel* (PLDV; Linear Equation in Two Variables) as a *Persamaan Linear Satu*

*Variabel* (PLSV; Linear Equation in One Variable). This aligns with the research of Sari (2023), which highlights students' struggles in transitioning from contextual problems to accurate symbolic representations.

Additionally, a new correlational misconception was identified—students misinterpret mathematical representations, specifically interpreting "not less than" as "less than or equal to (≤)". This aligns with research by Taqiyuddin et al. (2017) which found that students misinterpret phrases when converting them into mathematical notation, such as interpreting "not more than" as "less than".

These findings emphasize the need to design instructional strategies that are responsive to students' learning styles, especially for visual learners. The use of visual-based learning tools—such as diagrams, graphs, and animations—can be effective in minimizing misconceptions by clearly demonstrating the processes involved in solving equations and inequalities. These approaches support deeper understanding of abstract algebraic concepts like variables and operational rules.

In addition, teachers should guide students in converting verbal or contextual information into mathematical form by using analogies and visual scaffolds that make abstract ideas more accessible. Providing targeted feedback can also help students distinguish between arithmetic and algebraic operations, thereby reducing conceptual and procedural errors. This approach is consistent with the findings of Sari (2023) who emphasized that structured and repeated practice in using multiple representations can significantly reduce misconceptions. Ultimately, strengthening teaching methods to better accommodate students' preferred learning styles is not only crucial for improving performance in algebraic numeracy but also vital for preparing students to meet more complex mathematical challenges in the future.

## Conclusion

Visual learners experience theoretical misconceptions, including errors in understanding the concept of variables and PtLSV, misapplication of algebraic operation principles, and flawed reasoning when answering questions. Additionally, they also demonstrate correlational misconceptions, such as difficulties in converting known information into mathematical form and errors in representing concepts through various mathematical representations.

These misconceptions often arise from students' incomplete or inaccurate initial understanding of concepts and their reliance on associative thinking. Therefore, it is essential for teachers to assess students' prior knowledge through diagnostic testing, enabling early identification and remediation of conceptual errors before students engage with more complex material.

This study recommends further research involving students with other learning styles, such as auditory and kinesthetic learners, to broaden the understanding of how learning styles relate to mathematical misconceptions. Future studies could also examine the effectiveness of instructional strategies—such as context-based learning or problem-based learning—in reducing misconceptions across different learner types. Ultimately, the findings of this study are expected to contribute to the development of more inclusive and effective instructional strategies that address the diverse learning needs of all students.

## Declarations


| | | |
|---|---|---|
| Author Contribution | : | ZE: Conceptualization, Methodology, Investigation, Writing - Original Draft, Formal Analysis, Editing and Visualization.<br>NDSL: Methodology, Writing-Review & Editing, Formal Analysis and Visualization.<br>EO: Methodology, Writing-Review & Editing, Formal Analysis.<br>DT: Validation and Supervision.<br>LNS: Validation and Supervision. |
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