

Investigating Students' Mathematical Problem-Solving Errors on Relations and Functions Through Newman's Error Analysis

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ABSTRACT

Purpose – Students' mathematical problem-solving ability remains low, particularly in the topic of relations and functions, as evidenced by frequent errors in solving problem-solving tasks. This study aims to identify and analyze the types of errors made by eighth-grade students in solving mathematical problem-solving questions on relations and functions using Newman's Error Analysis.

Methodology – This study employed a qualitative, descriptive research design. The participants were 29 Grade VIII.6 students from State Junior High School 1 Rambah. Data were collected through written problem-solving tests, semi-structured interviews, and documentation. The data were analyzed using Newman's Error Analysis framework, which includes reading, comprehension, transformation, process skills, and encoding stages, following the steps of data reduction, data display, and conclusion drawing.

Findings – The results indicated that the least frequent error was reading errors (36.2%), followed by comprehension errors (91.4%) and transformation errors (89.7%). The most frequent errors were process skills errors and encoding errors, each occurring in 100% of students' responses. These findings suggest that students experience significant difficulties in executing mathematical procedures and expressing final answers correctly.

Novelty – This study provides a detailed error profile of students' problem-solving processes on relations and functions using Newman's Error Analysis, highlighting critical stages where students consistently fail.

Significance – The findings benefit mathematics teachers, curriculum developers, and researchers by providing insights into common student errors and supporting the development of instructional strategies that utilize students' errors as learning resources to improve problem-solving ability.

Keywords: Newman's procedure; Problem-solving; Relations and functions; Student errors.

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1. Introduction

Mathematical problem-solving skills are one of the main goals of mathematics learning because they can train students to think logically, critically, and systematically (Hayu & Angraini, 2024; Nasrullah, Yendra, Ratnasari & Khan, 2024; Loska, Ayuni & Ainirohmah, 2024; Parindang, Ramlan, Wahyuni & Salman, 2025; Dhani, Nurrahmawati, Afri & Khan, 2025; Devan, Angraini & Sadiq, 2025). However, international studies such as PISA and TIMSS show that Indonesian students' mathematical ability remains relatively low, especially in problem-solving. This condition was also found at State Junior High School 1 Rambah, where the initial test results showed that students still made many mistakes in solving problems on the relationship and function material. This material requires a good understanding of concepts, the ability to convert information into mathematical models, and precision in calculations, but many students struggle with these stages.

Analysis of student errors is essential to help teachers find out where mistakes are and their causes, so that more appropriate learning strategies can be designed (Cahyani, Iskandar, Sukmawati & Raza, 2024; Sa'dah, Afri, Nurrahmawati & Arcat, 2025; Suryani, Nurrahmawati, Afri & Arcat, 2025; Mulya, Darwati & Inayah, 2024; Madya, Angraini & Bonyah, 2025; Apriliani, Kania & Umar, 2025; Ashari, Mayda & Wahyuni, 2025). The Newman procedure is one of the effective methods to identify students' mistakes in solving problem-solving problems. By applying this procedure to the relationship and function material, teachers can get a clear picture of the most common types of errors and the corrective steps needed.

Several previous studies have analyzed students' errors in solving mathematical problems using Newman's procedures. For example, research by Nurfalalah et al. (2021) found that process skills errors are the most common. Lulu Amatul Wahid's (2022) research on the relationship and function material shows that students often make mistakes in understanding problems and writing final answers. Abidin & Kadir's (2020) research also identified misunderstandings, transformations, process skills, and writing final answers. However, these studies differ in the materials, subjects, and study foci.

Based on previous studies, many have analyzed students' errors across various mathematics materials, but studies that specifically examine grade VIII students' errors in material on relationships and functions using the Newman procedure remain limited. Moreover, a study that maps the percentage of each type of error in detail in the context of State Junior High School 1 Rambah has not been found.

The ability of students in Indonesia to solve mathematical problems is still low, especially in relation to and function materials. Some researchers focus on analyzing student errors with the Newman procedure on other material or with different subjects. There is little research that discusses in depth the mistakes of grade VIII junior high school students in the material on relationships and functions at State Junior High School 1 Rambah. Therefore, this study aims to analyze the types of student errors in solving problems in relationships and functions using the Newman procedure.

2. Methods

This study uses a qualitative, descriptive approach. This study aims to identify and analyze the mistakes made by grade VIII students in solving problems of relationships and functions. The population in this study consists of 29 students in grade VIII.6 at State Junior High School 1 Rambah. The sample was selected by a purposive sampling technique with certain

considerations. The considerations in this study are students who are willing and cooperative to be interviewed, able to communicate their thinking processes verbally, and who have errors in certain parts of both questions. Then, 2 students were selected as research subjects who made reading errors, misunderstandings, transformation errors, process skills errors, and final answer writing errors. So the number of interviewees was 10 students.

Data collection in this study was conducted through three methods: tests, interviews, and documentation. The test is given in the form of problem-solving questions on relationship and function materials to identify the types of mistakes students make. Furthermore, interviews were conducted with several selected students based on test results, with the aim of digging deeper into their thought processes and the cause of errors. Meanwhile, documentation is used as a complement, in the form of records, archives, or other data that support the validity of research results. The following is presented in Figure 1: one example of the questions tested.

Mr. Andi has a store that sells two types of superior products, namely sports hats and sports shirts. The price of sports hats is IDR 50,000 per unit and the price of sports shirts is IDR 80,000 per unit. The store wants to sell 100 units of sports caps and 50 units of sports shirts. However, to increase sales, Mr. Andi decided to give a 10% discount for sports hats and 15% for sports shirts. Function for sports cap income: $T(x) = 50,000x$ and sports shirt: $K(y) = 80,000y$.

Calculate the total income earned by Mr. Andi before the discount and after the discount! If the production cost for 100 units of sports hats is IDR 4,000,000 and for 50 units of sports shirts is IDR 2,400,000, does Mr. Andi experience a profit or loss after giving a discount? Explain your reasoning!

Figure 1. Test Instruments

The data obtained were analyzed using a qualitative descriptive method guided by the Newman procedure. The analysis starts with data reduction and data presentation and culminates in drawing conclusions. The Newman procedure identifies five types of student errors: reading errors, misunderstanding the problem, transformation errors, process skills errors, and final answer errors. The interview data were then used to strengthen the findings of the written test, enabling a more in-depth and comprehensive analysis of the errors identified. To maintain the credibility of the data, the researcher applied source triangulation, comparing the results of error analysis on the answer sheet with those of student interviews.

The scoring rubric and the Newman procedure used to identify student errors are presented in Table 1.

Table 1 - Description of Student Errors Based on Newman Procedure

Aspects	Max Score	Remarks
Reading Errors	2	0. Not writing mathematical words/symbols 1. Writing mathematical words/symbols, but not exactly/incompletely 2. Write mathematical words/symbols correctly.
Comprehension error	3	0. Students do not write down what they know and are asked in the questions 1. Students write down what they know or are asked,

Aspects	Max Score	Remarks
Transformation error	2	<p>but do not match the question request.</p> <p>2. Students write down what they know and what is asked, but it is not in accordance with the question request / incomplete.</p> <p>3. Students write down what they know and what is asked according to the question request.</p> <p>0. Students do not write down mathematical models or formulas in solving problems at all.</p> <p>1. Students write mathematical models or formulas in solving problems, but they are not complete/precise.</p> <p>2. Students can write down the formula used in solving the problem exactly and accurately</p>
Process skill error	4	<p>0. Students cannot do calculations in solving problems at all</p> <p>1. Students do not do calculations when looking for answers; they directly write down the final answer, and the final answer is wrong.</p> <p>2. Students do calculations in looking for answers with the wrong steps, and the final answer is wrong because the method used is wrong.</p> <p>3. Students do calculations and process steps leading to the correct answer, but the final answer is wrong</p> <p>4. Students can do calculations correctly when looking for answers with the process, and the final answer is correct.</p>
Encoding error	2	<p>0. Students do not write down conclusions at all.</p> <p>1. Students write conclusions, but they are not complete and precise</p> <p>2. Students can write down their conclusions completely and correctly.</p>

3. Results and Discussion

3.1 Results

The data of this study were obtained from a description test given to 29 students at State Junior High School 1 Rambah. The test consists of 2 questions, each representing 4 stages of mathematical problem-solving: understanding the problem, planning to solve the problem, solving the problem, and doing a double-check. Based on the results of written tests from 29 students on solving problems related to functional materials, several errors were identified using the Newman procedure: reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors. During the research process, the researcher collected data from students' work results. The students' work was corrected to identify the types of mistakes they made while solving the problems.

Table 2 - Description of Student Errors Based on the Newman Procedure

Types of errors	Questions No 1	Percentage (%)	Questions No 2	Percentage (%)	Average Percentage
Reading	12	41,4	9	31	36,2

Types of errors	Questions No 1	Percentage (%)	Questions No 2	Percentage (%)	Average Percentage
Comprehension	27	93,1	26	89,7	91,4
Transformation	28	96,6	24	82,8	89,7
Process Skill	29	100	29	100	100
Encoding	29	100	29	100	100

Based on Table 2, the least mistakes students make are reading errors, and the most mistakes are in process skills and drawing conclusions. Pie charts regarding the distribution of student errors based on the Newman procedure are presented in Figure 1.

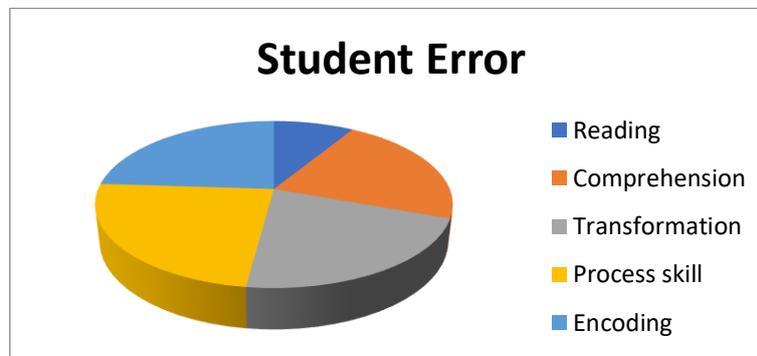


Figure 2. Test Instruments

3.1.1 Reading error

Based on Figure 2, there is an error in reading the question. It can be seen in AI Subjects and DE Subjects who miswrite and read the mathematical formulas in questions 1 and 2. Mistakes in reading this question can hinder students' understanding and ability to solve the problem, leading to an inappropriate solution. The following are the results of the Researcher (P) interview, along with pictures of the mistakes made by the AI Subjects (S1) and DE Subjects (S2) to clarify the students' mistakes.

P : *Try to read the formula in the question!*

S1 : *"ef in parentheses te equals Fo plus at", "er times equals fifty times minus zero comma one times two" and "ce in parentheses times equals ten times plus five hundred"*

S2 : *"er in the ex bracket is equal to fifty minus zero times two"*

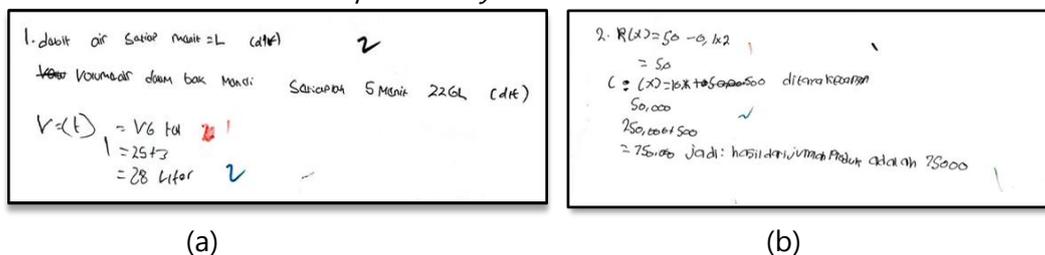


Figure 3. (a) Subject 1 and (b) Subject 2 in Reading error

Based on the interview results, the student's mistake, among others, was due to an inability to recognize mathematical symbols and to write formulas accurately. This aligns with the findings of Widada & Priyono (2019), who stated that students often fail to recognize the symbols or mathematical terms used in the problem, thereby leading to errors in the early stages of solving.

3.1.2 Comprehension error

Based on Figure 3, there is an error in understanding the problem, as seen in the IK Subject and the AJ Subject, who are not precise/complete in writing and understanding what is known and what is asked in the question. The following are the results of the Researcher (P) interview and pictures of student mistakes in the IK Subject (S1) and AJ Subject (S2) to clarify student mistakes.

- P : "Try to explain what is known and asked in the question?"
 S1 : "If the question number 1 is known, the discharge of the water is $A = 3$ liters. And $V(t) = V_0 + at$, the volume of water in the bath after 5 minutes is 25 liters. The question is to determine the volume of water in the bath after 27 minutes." Question No. 2 is the answer."
 S2 : "The water discharge that flows every minute is 3 liters; the volume of water in the bathtub after 5 minutes is 25 liters. Is it possible to determine the volume of water in the bathtub after 27 minutes?" If number 2 (S2 reads sumua questions)"
 P : "Why are you wrong or incomplete in writing what is known and asked in the question?"
 S1 : "Lack of focus and lack of attention, also because of the rush."
 S2 : "Not very smart, because I am not used to writing what is known and asked."

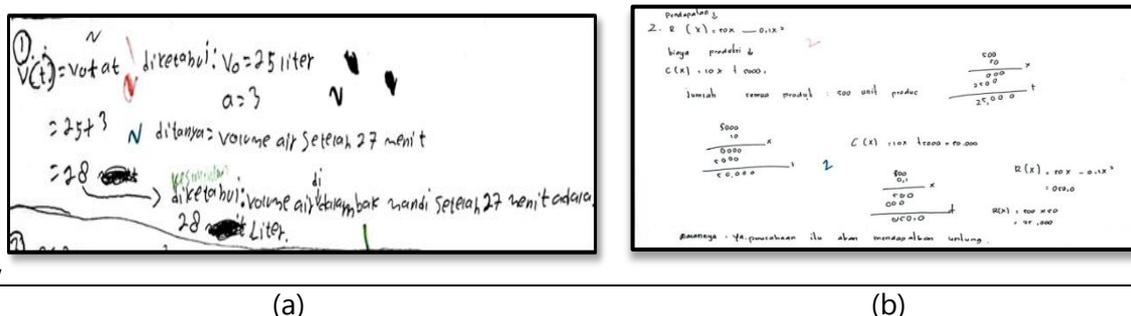


Figure 3. (a) Subject 1 and (b) Subject 2 in Comprehension Error

Based on the interview results, the mistake occurred because the student did not understand the problem, so it was written incorrectly, and the student hurriedly solved it. As stated by Yeni Rosita (2020), based on their research, misunderstandings occur because students are unable to understand the problem's meaning, are not accustomed to expressing known information, do not read the problem thoroughly, and are in a hurry to solve it.

3.1.3 Transformation error

Based on Figure 3, it can be seen that the NA Subject and the AP Subject tried to work on the solution; however, it was wrong not to write down the formula used to solve the problem. In question no. 1, Subject NA wrote an incomplete formula, so it incorrectly searched for the values of V_0 and $V(27)$. In question no. 2, Subject AP incompletely wrote a formula to seek company profits, so the answer was ultimately wrong. The following are the results of the Researcher (P) interview and pictures of the mistakes made by the NA Subject (S1) and AP Subject (S2) to clarify the students' mistakes.

- P : "Try to pay attention to the problem, what to solve/look for in the question, is there a formula that you use to solve the problem?"
 S1 : "I use the formula in question, just put it in."
 S2 : "I know, but I'm guessing it's the right thing to do."
 P : "Take a look at your answer sheet. Why did you calculate the wrong formula, and did you see your friend's answer?"
 S1 : "I have read the question, but I don't understand the meaning of the formula and am

not good at entering the correct number."

S2 : "The problem is convoluted, so I'm confused about entering the right number into the formula so I try to find it myself my way, because I'm even more confused because I have a little answer for a friend, hehe"

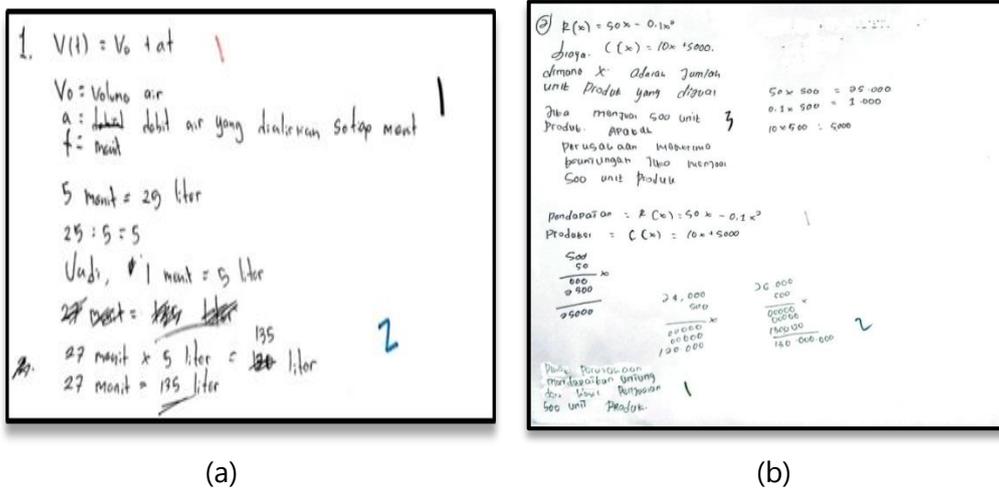


Figure 4. (a) Subject 1 and (b) Subject 2 in Transformation error

Based on the interview results, the error occurred because the student did not understand which mathematical formulas/models should be used to solve the problem completely, and did not know how to calculate using the formula. This aligns with the research of Miranda, P., Sumartono, S., & Prastiwi, L. (2024), which states that transformation errors occur when students use the wrong approach or formula to solve a problem.

3.1.4 Process Skill Error

Based on Figure 4, it can be seen that RM Subject and LA Subject attempt to calculate an answer, but there are still errors in the calculation process, and the calculation is not complete/accurate, so the final answer obtained is incorrect. The following are the results of the Researcher (P) interview and pictures of the mistakes made by the RM (S1) and LA (S2) Subjects to clarify the students' mistakes.

- P : "Please pay attention to the problem. What needs to be solved or determined in the question? Is there any formula that you use to solve it?"
- S1 : "I used the formula provided in the question; I just needed to substitute the values."
- S2 : "There is a formula, but I calculated it randomly by guessing."
- P : "Please look at your answer sheet. Why did you make mistakes when using the formula, and did you look at your friend's answer?"
- S1 : "I have read the question, but I did not fully understand the meaning of the formula and I was not good at substituting the correct numbers."
- S2 : "The question was complicated, so I was confused about which numbers to substitute into the formula. I tried to solve it in my own way, and because I became even more confused, I looked briefly at my friend's answer."

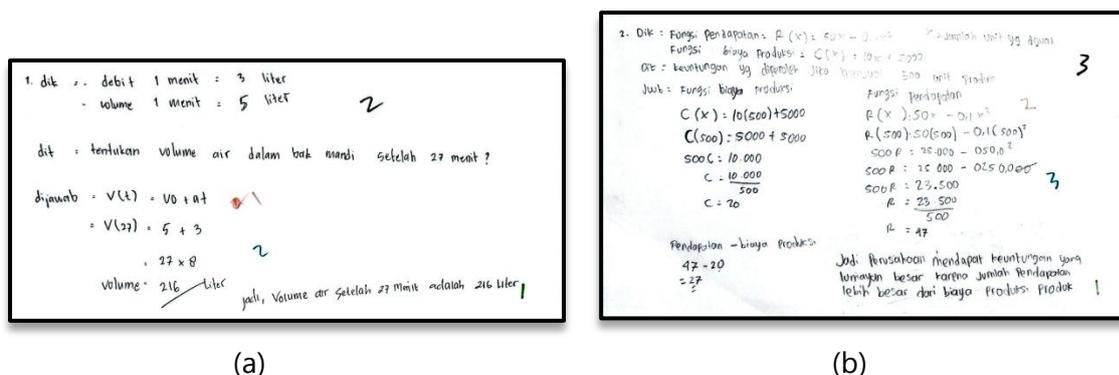


Figure 5. (a) Subject 1 and (b) Subject 2 in Process Skill Error

Based on the interview results, the students made mistakes in the steps used to perform incorrect calculations, and the final answer was incorrect. In line with Rahmayanti & Maryati's (2022) research, which explains that process skill errors occur because students are unable to use mathematical calculation procedures correctly, often due to a lack of understanding of formula substitution, forgetting formulas, not being thorough, or being in a hurry.

3.1.5 Encoding error

Based on Figure 5, it can be seen that Subject NV and Subject AB are not appropriate for writing conclusions or writing final answers. The following are the results of the interview with the Researcher (P) and pictures of the mistakes of the students of Subject NV (S1) and Subject AB (S2) to clarify the mistakes of the students.

P : "Have you found the final answer? Is the conclusion you have come to correct?"

S1 : "I know, but I don't think I'm going to be able to make a decision. I think it's a good idea."

S2 : "Yes, but I didn't write it down because I had doubts, and I deleted the conclusion".

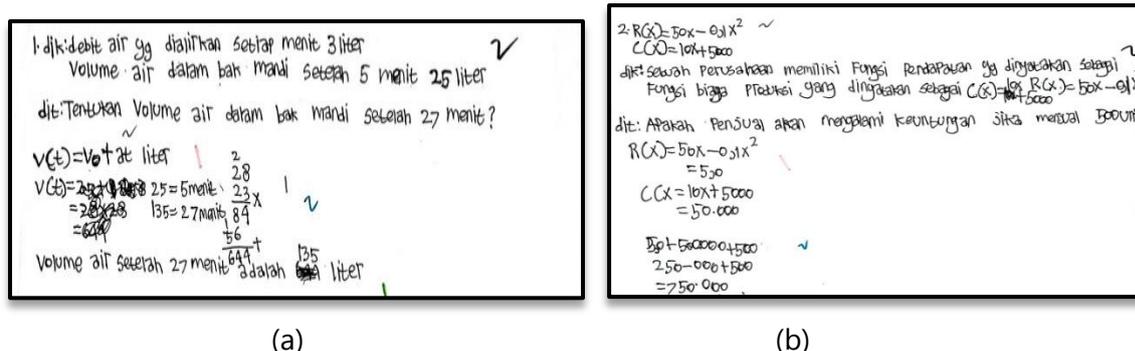


Figure 6. (a) Subject 1 and (b) Subject 2 in Encoding errors

Based on the interview results, the mistake is that the student either does not write a conclusion at all or writes one that is inaccurate or incomplete. This is because students are unable to pass the previous stage correctly, namely, completing the process skills. Writing final answers is also the most common source of mistakes for students. This aligns with research by Halim & Rasidah (2019), which found that the most common mistakes students make in solving problems are writing final answers incorrectly and transformation errors.

3.2 Discussions

Based on the data processing results, it can be seen that students' mistakes in solving problems on the function material are still classified as high in almost all stages of the Newman

procedure. Out of 29 students who took the test, the highest percentage of mistakes was found in the aspects of process skill and encoding, with an average reaching 100%, while the lowest mistakes were found in the reading aspect, with an average of 36.2%. This finding shows that although some students are able to read the questions relatively well, they still experience difficulties in the subsequent stages of the problem-solving process.

Reading errors became the type of error with the lowest percentage compared to other categories, which were 41.4% on question number 1 and 31% on question number 2. Nevertheless, this figure still shows that more than a third of students made mistakes in correctly recognizing symbols or reading mathematical formulas. Errors at this initial stage affect subsequent stages because conceptual understanding heavily depends on the ability to read and recognize symbols accurately. This aligns with the findings of Widada & Priyono (2019), who stated that students often fail to recognize the symbols or mathematical terms used in the problem, thereby leading to errors in the early stages of solving.

Comprehension errors have a very high average percentage, namely 91.4%. This indicates that most students have not been able to identify the information that is known and that is asked in the questions completely and accurately. Based on the results of the interviews, factors such as lack of focus, haste, and not being accustomed to writing down the given and asked elements are the main causes. This condition indicates the need for habituation in learning to write down the initial steps of problem-solving systematically.

Transformation errors also show high numbers with an average of 89.7%. Students tend to be unable to determine the correct formula or mathematical model to solve problems. Some students even just copy the formula without understanding its meaning or make incorrect substitutions of values. This indicates that students' conceptual understanding of the function material is still weak and needs to be strengthened through exercises that emphasize selecting problem-solving strategies. As stated by Yeni Rosita (2020), based on their research, misunderstandings occur because students are unable to understand the problem's meaning, are not accustomed to expressing known information, do not read the problem thoroughly, and are in a hurry to solve it.

Errors in the process skill stage reached 100% on both questions. This means that all students made mistakes in the calculation process or problem-solving procedures. These errors include mistakes in substituting values, incorrect arithmetic calculations, and disorganized problem-solving steps. The high percentage of these errors indicates that students have difficulties not only in understanding the concepts but also in correctly applying calculation procedures. In line with Rahmayanti & Maryati's (2022) research, which explains that process skill errors occur because students are unable to use mathematical calculation procedures correctly, often due to a lack of understanding of formula substitution, forgetting formulas, not being thorough, or being in a hurry.

Furthermore, the error in writing the final answer (encoding error) also reached 100%. Many students did not write the conclusion completely or did not write it at all. Some students admitted to doubting their answers, so they chose to erase or not write the final conclusion. This indicates low self-confidence among students as well as a lack of habit in rechecking the results they have obtained.

If viewed from the interconnection between stages, errors at the final stage are generally the accumulation of errors from the previous stages. When students make mistakes in understanding the problem and transforming it into a mathematical model, then errors in calculation processes and writing conclusions become unavoidable. Thus, each stage in the

Newman procedure is interconnected and forms a complete sequence of thinking processes. This aligns with the research of Miranda, P., Sumartono, S., & Prastiwi, L. (2024), which states that transformation errors occur when students use the wrong approach or formula to solve a problem.

The results of this study also show that students tend to rush in completing problems and are less careful in each step of the solution. Factors such as study habits that do not emphasize conceptual understanding and systematic thinking processes also contribute to the high error rates. Learning that emphasizes procedural practice without deep understanding is likely one of the main causes.

Pedagogically, these findings imply that teachers need to design learning that emphasizes strengthening each stage of problem-solving. Teachers can accustom students to read questions slowly, write down the information known and asked, choose the correct formulas, perform calculations systematically, and write conclusions clearly. In addition, reflection exercises and rechecking answers also need to be implemented to minimize errors at the final stage. This aligns with research by Halim & Rasidah (2019), which found that the most common mistakes students make in solving problems are writing final answers incorrectly and transformation errors.

Overall, the research results show that students' mistakes in solving function problems do not only occur in a particular aspect, but in almost all stages of the Newman procedure, with errors dominating in process skills and the writing of the final answer. Therefore, comprehensive and continuous efforts to improve learning are needed so that students' mathematical problem-solving abilities can improve optimally.

4. Conclusions

This study analyzes the types of student errors in solving problems solving relational and functional problems based on the Newman procedure. Of the 10 students who were the subjects of this study, the reading errors were 36.2%, the misunderstanding errors were 91.4%, the transformation errors were 89.7%, and the process skills errors and final answer writing errors were both 100%. It is hoped that teachers will always provide questions based on HOTS descriptions so that students are used to solving problem-solving problems, practice story-based mathematics problems, and be thorough and not rush through math problems. This research is expected to provide information for future researchers to conduct the same research on different materials or at different levels of education.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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