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Analysis of Student Errors in Solving Trigonometry Story Problems Based on Newman's Theory

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Abstract

This research aims to analyze the types of errors and factors that cause errors made by students in solving trigonometry story problems based on Newman's theory. This study uses phenomenology as the research method. The subjects in this research were class X-2 students at SMKS Kitri Bakti for the 2023/2024 academic year, totaling 20 students. This research was conducted using a qualitative descriptive method. The research instrument is a description of 5 items that have been validated. The data collection techniques used were written tests, interviews and documentation. The results of the research that has been carried out show that the percentage of errors made by students in solving trigonometry story problems based on Newman's theory is: (1) Understanding errors made by students is 70%, (2) Transformation errors are 78%, (3) Process skill errors are 78%. 80%, (4) Errors in writing final answers were 75%. The percentage of students' total errors was 60.6%. The factors that cause student errors are that students are unable to write down the information contained in the problem, do not know the mathematical model, are in a hurry when solving the problem, and forget to write the final answer because they are in a hurry.

Keywords: Analysis of student errors, solving problems, trigonometry.

1 INTRODUCTION

One of the learning objectives set in the curriculum is that students have good problem solving competencies (Kemendikbud & M., 2016). The definition of problem solving according to (Montague, n.d.) is a complex cognitive activity accompanied by a number of processes and strategies. Problem solving ability is also a competency that graduates must have if they want to successfully compete in the 21st century industry (Tan, 2021). Conversely, graduates with low problem-solving abilities will be assessed as low-quality human resources (Kurniawati et al., 2019). Through this analysis, the type and location of errors can be obtained, so that educators can provide appropriate solutions as a form of improving the learning process. Therefore, the mistakes students make in solving mathematical problems are very important, so that in the future educators can formulate alternative solutions to the problems students face.

According to (Ainin, 2020) the mistakes made by students need to be analyzed to find out the various types of mistakes made by students. Through this analysis, the type and location of errors can be obtained, so that educators can provide appropriate solutions as a form of improving the learning process. Apart from that, teachers can use students' mistakes as information to make learning efficient. Analysis of the mistakes made by students in solving mathematical problems is very important, so that in the future educators can formulate alternative solutions to the problems faced by students.

Trigonometry material is mathematical material related to triangle angles and trigonometric functions (Kariadinata, 2013). Based on interviews with mathematics teachers at the Kitri Bakti Vocational School, North Cikarang, researchers obtained

information regarding the cognitive scores of class X-2 students which were still relatively low, especially in trigonometry material. To strengthen the teacher's opinion, the researcher then gave trigonometry test questions in the form of stories. The results of the trigonometry test showed an average score of 54.15, which is relatively low. The process of analyzing student errors in this research will focus on trigonometry story problems, where to this day trigonometry story problems are still seen as mathematical problems that are difficult for students to solve (Pratiwi & Trigonometry, 2021). Therefore, to analyze students' errors in solving mathematics story problems can be done using error analysis using Newman's theory.

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Newman Error Analysis (NEA) was first introduced in 1977 by Newman, a mathematics teacher in Australia. Newman classifies students' errors in completing mathematical problem solving. The following classification stages by Newman include reading errors, comprehension errors, transformation errors, process skills errors, and so on (Suhaeti et al., 2021). In analyzing student errors based on Newman's theory, there are 5 stages used in analyzing an error made by students when solving mathematics story problems, namely: (1) Reading errors occur because students are unable to read or recognize symbols and students cannot explain the meaning. of every word, term, or symbol in the question; (2) Comprehension errors occur because students are unable to fully understand what is completely known in the question; (3) Transformation errors occur because students cannot create mathematical models according to the information in the problem and students do not know what formulas will be used when solving the problem; (4) Process skill errors occur because students do not know the procedures or steps that will be used to solve the problem and students are unable to carry out the procedures or steps correctly; (5) Errors in writing final answers (Encoding errors) occur because students cannot find the final result based on the procedures or steps used, students cannot show the final answer by solving the question correctly and students cannot write the final answer based on the conclusion intended in the question. (Annisa & Kartini, 2021). The way to solve math story problems based on Newman's theory is: (1) Read the question; (2) State the question you are asked to answer; (3) Explain the approach used to find a solution; (4) Demonstrate the steps that have been explained and how to think to find the answer; (5) Write the conclusion answer (Irianti et al., 2022).

According to (Ufi Dwidarti, Helti Lygia Mampouw, 2021) mathematics story problems are mathematical problems expressed in story-form sentences which need to be translated into mathematical sentences or mathematical equations. Mathematics story problems are mathematics questions that contain problems in everyday life which are packaged in the form of short stories to be translated into sentences or mathematical equations. Mathematics story problems provide a real picture of real life problems. Providing story problems is intended to introduce students to the benefits of mathematics in everyday life and to train students' abilities in solving mathematical problems in everyday life (Azis, 2019). The steps that must be taken in solving story problems are: (1) Reading the questions; (2) Determine what is known and what is asked; (3) Create a mathematical model; (4) Carrying out calculations; (5) Write the final answer correctly (Wilyana Selvia, 2023). Thus, in solving word problems, students need to be careful in understanding the

reading questions to ensure that they understand what they read, students also need more time to understand the text of difficult questions, because students have to pay attention, visualize the information to help remember and understand clearly. what is read. According to (Mulyadi & Fiangga, 2021) the factors that cause errors are caused by cognitive and non-cognitive factors, and the steps for solving them according to Newman are: (1) Factors that cause reading errors, namely when students do not understand the meaning of the words in the question; (2) Factors that cause errors in understanding, namely students do not understand the problem in the question, which results in students being unable to determine what is known and asked in the question; (3) Factors causing transformation errors, namely students have understood the problem, but cannot change the problem into mathematical form; (4) Factors that cause process skills errors, namely students cannot solve problems because students do not understand the process of calculating numbers to solve problems; (5) The factor that causes errors in writing the final answer is that the student has completed all the steps correctly, but the student is used to the habit of solving story problems without returning the model answer to answer the problem requested by the question.

2 RESEARCH METHODS

According to (Ufi Dwidarti, Helti Lygia Mampouw, 2021) mathematics story problems are mathematical problems expressed in story-form sentences which need to be translated into mathematical sentences or mathematical equations. Mathematics story problems are mathematics questions that contain problems in everyday life which are packaged in the form of short stories to be translated into sentences or mathematical equations. Mathematics story problems provide a real picture of real life problems. Providing story problems is intended to introduce students to the benefits of mathematics in everyday life and to train students' abilities in solving mathematical problems in everyday life (Azis, 2019). The steps that must be taken in solving story problems are: (1) Reading the questions; (2) Determine what is known and what is asked; (3) Create a mathematical model; (4) Carrying out calculations; (5) Write the final answer correctly (Wilyana Selvia, 2023). Thus, in solving word problems, students need to be careful in understanding the reading questions to ensure that they understand what they read, students also need more time to understand the text of difficult questions, because students have to pay attention, visualize the information to help remember and understand clearly. what is read. According to (Mulyadi & Fiangga, 2021) the factors that cause errors are caused by cognitive and non-cognitive factors, and the steps for solving them according to Newman are: (1) Factors that cause reading errors, namely when students do not understand the meaning of the words in the question; (2) Factors that cause errors in understanding, namely students do not understand the problem in the question, which results in students being unable to determine what is known and asked in the question; (3) Factors causing transformation errors, namely students have understood the problem, but cannot change the problem into mathematical form; (4) Factors that cause process skills errors, namely students cannot solve problems because students do not understand the process of calculating numbers to solve problems; (5) The factor that causes errors in writing the final answer is that the student has completed all the steps correctly, but the student is used to the habit of solving story problems without returning the model answer to answer the problem requested by the question.

This research was carried out in class X of SMKS Kitri Bakti. The method used in this research is a qualitative descriptive method which aims to show more carefully students' mistakes in working on trigonometry story questions guided by Newman's theory. The type of research used in this research is phenomenology. Phenomenological research is scientific research that examines and investigates an event experienced by an individual, a group of individuals, or a group of living creatures (Moleong, 2018).

The instruments used in this research were trigonometry story questions and interviews. This question is structured in the form of a description of trigonometry. The test instrument used in this research is diagnostic, meaning it only wants to know where students made errors and the factors that caused students to make errors. The research stages began with giving trigonometry problem solving questions to research subjects totaling 20 students. There are 5 trigonometry problem solving questions whose validity has previously been tested. Students must complete these questions within 60 minutes. After the students completed the questions given, the researcher checked the results of the subject's answers to identify the types of errors the students made. From the results of the subject's answers, the researcher then conducted unstructured interviews with 3 students as sources who represented the answers to each question. How to choose students as subjects to be interviewed based on the mistakes made by students in solving trigonometry story problems based on Newman's theory and where the 3 research subjects were chosen based on the level of error. The ability level criteria used are 2 students in the medium ability level category and 1 student in the low ability level category. This interview aims to find out the types of errors, and the factors that cause students to make mistakes in solving trigonometry story problems.

Then the 3 research subjects will be interviewed to obtain information on the factors that cause errors based on Newman's theory. The selection of interview subjects was based on the results of written answers and the results of the class X mathematics teacher's considerations. Data collection in this research was carried out using a written test, where the test consisted of 5 questions whose validity had previously been tested. The way to carry out validity is by reviewing each test question with the help of validators who are experts in mathematics, namely mathematics lecturers and mathematics teachers who are experts in mathematics, interviews and documentation. Checking the validity of the data is by using triangulation. This triangulation technique is carried out by checking data from the same source with different techniques, namely by conducting tests, interviews and documentation. The data analysis techniques used are data reduction, data presentation, and drawing conclusions.

3 RESULT AND DISCUSSION

The results of this research are the types of errors and factors that cause errors made by the three research subjects in solving trigonometry story problems. Below we will present the results of the work of class X-2 students at Kitri Bakti Vocational School.

3.1 Error Model in Problem Number 1

Some mistakes made by S-3 students in question number 1:

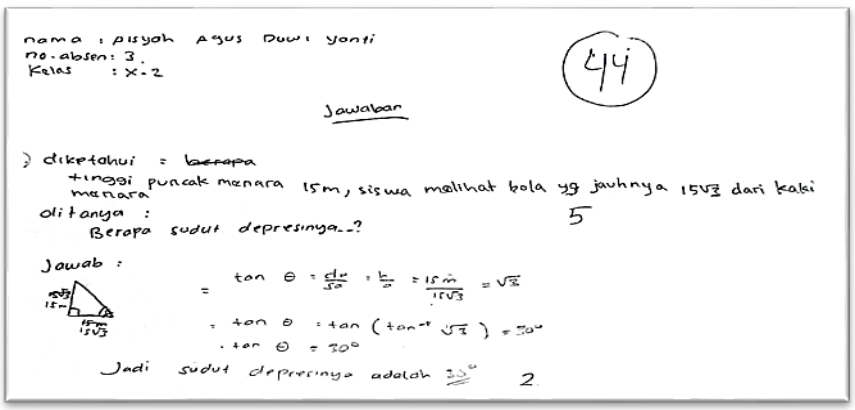

Figure 1.

Figure 1. Results of S-3 students' answers to question number 1. From the results of students' answers, it can be seen that S-3 students made process skill errors and errors in writing final answers (Encoding errors) when solving trigonometry story questions. To be clearer about the mistakes made by students, you can see the data analysis table presented in table 1.

Table 1. S-3 Data Analysis Results

Error Type	Test Discussion Analysis	Analysis of Interview Results
Process Skill Errors	(1) Students make mistakes in arithmetic operations. (2) Students do not understand the calculations.	(1) Students do not understand the calculations used. (2) Students are less careful about their results.
Error Final Answer Writing (Encoding Errors)	Students are less careful when solving questions. This results in the final answer being wrong and the conclusion being wrong.	Students are in a hurry when working on questions. So the final answer and writing of the conclusion are wrong.

3.2 Error Model in Problem Number 2

Some mistakes made by S-10 students in question number 2:

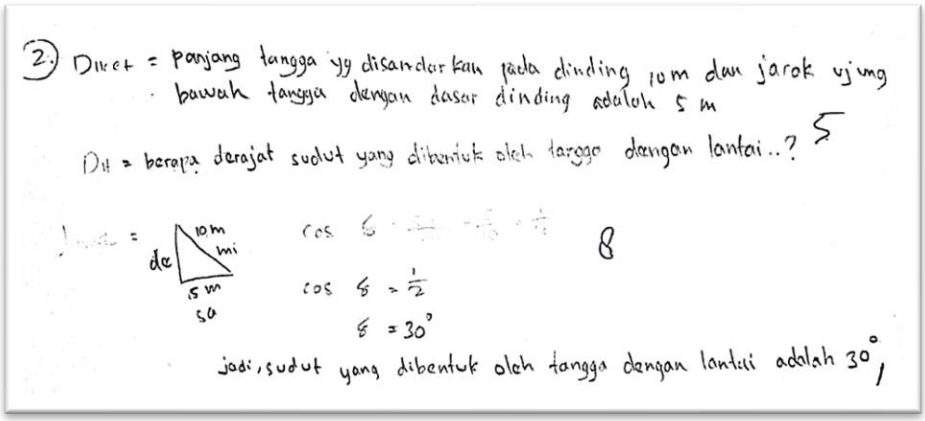

Figure 2.

Figure 2. Results of S-10 Students' Answers to Question Number 2. From the results of the students' answers, it can be seen that S-10 students made errors in writing the final answers (Encoding errors) when solving trigonometry story problems. To be clearer about the mistakes made by students, you can see the data analysis table presented in table 2.

Table 2. Results of S-10 Student Data Analysis

Error Type	Test Discussion Analysis	Analysis of Interview Results
Error Final Answer Writing *(Encoding Errors)*	Students make mistakes in writing the final answer.	Students are less careful when calculating the results of the calculations in the questions. So writing the conclusion is wrong.

3.3 Error Model in Problem number 3

Some mistakes made by S-18 students in question number 3:

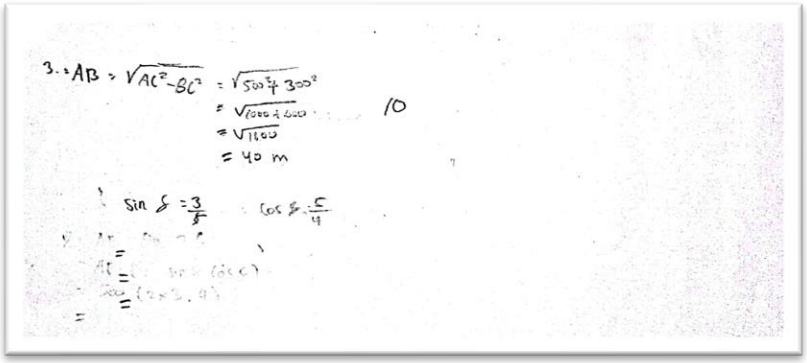

Figure 3.

Figure 3. Results of S-18 Students' Answers to Question Number 3. From the results of students' answers, it can be seen that S-18 students made Comprehension errors, Transformation errors and Encoding errors. when solving trigonometry word problems. To be clearer about the mistakes made by students, you can see the data table presented in table 3.

Table 3. Data Analysis Results for S-18 Students

Error Type	Test Discussion Analysis	Analysis of Interview Results
Error Misunderstanding (Comprehension Errors)	Students do not write down what they know and what is asked in the question.	Students do not understand the meaning of the question.
Transformation Errors	Students do not write mathematical models well.	Students do not know the mathematical model.
Error Writing Final Answers (Encoding Errors)	Students cannot continue the problem solving process.	(1) Students cannot do questions. (2) Students cannot determine the answer.

3.4 Error Model in Question number 4

Some mistakes made by S-3 students in question number 4:

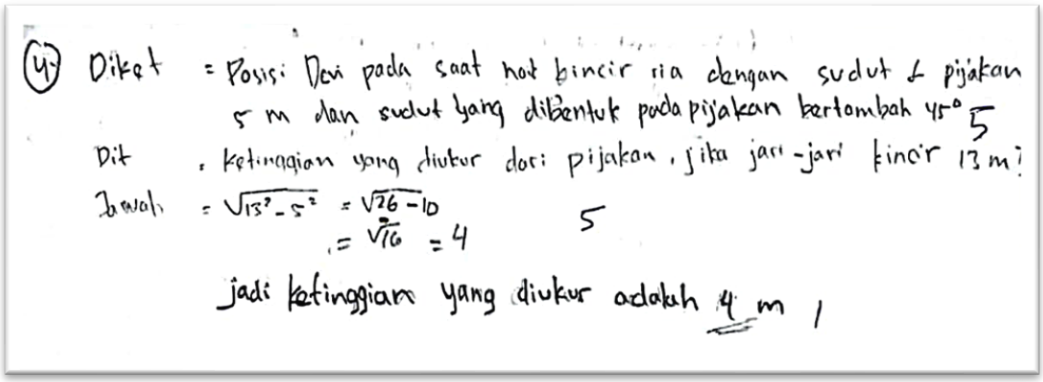

Figure 4.

Figure 4. Results of S-3 students' answers to question number 4. From the results of students' answers, it can be seen that S-3 students made processing skills errors

(Comprehension errors) and errors in writing final answers (Encoding errors) when solving trigonometry story problems. To be clearer about the mistakes made by students, you can see the data table presented in table 4.

Table 4. Data Analysis Results for S-3 Students

Error Type	Test Discussion Analysis	Analysis of Interview Results
Process Skill Errors	Students experience errors in performing arithmetic operations to find squares.	Students are not careful enough to calculate the square incorrectly.
Error Final Answer Writing (Encoding Errors)	Due to students' mistakes, they were not careful in working on the questions so they experienced errors in writing the final answer and conclusion.	Students are in a hurry when solving questions and there is a lack of student accuracy.

3.5 Error Model in Problem number 5

Some mistakes made by S-10 students in question number 5:

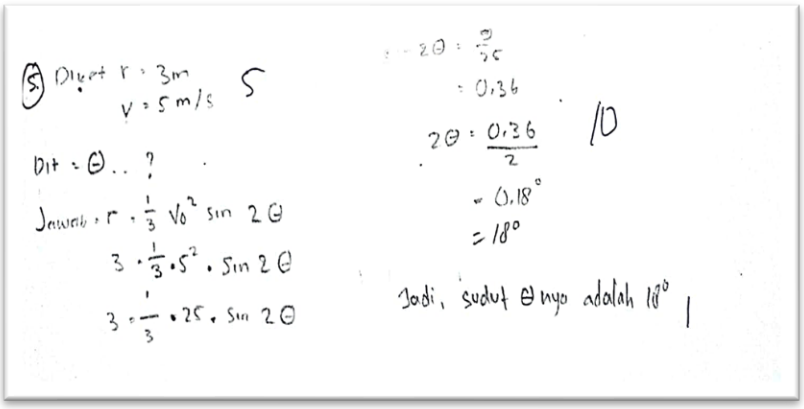

Figure 5.

Figure 5. Results of S-10 students' answers to question number 5. From the results of students' answers, it can be seen that S-10 students made processing skills errors (Comprehension errors) and errors in writing final answers (Encoding errors) when solving trigonometry story problems. To be clearer about the mistakes made by students, you can see the data table presented in table 5.

Table 5. Data Analysis Results for S-10 Students

Error Type	Test Discussion Analysis	Analysis of Interview Results
Process Skill Errors	Students make arithmetic operations errors.	Students do not understand the arithmetic operations in this problem. Error
Error Final Answer Writing (Encoding Errors)	Students experience errors in determining the final answer and writing conclusions. Students do not really understand the calculations of this problem.	So it's a mistake when writing the final answer and conclusion.

3.6 Models of Student Mistakes in Solving Problems

The following is a recapitulation of all the results of the analysis of students' mistakes in solving questions in the form of stories in everyday life in table 6.

Table 6. Combination of tables 1, 2, 3, 4, and 5

Error Type	Error Model	Factors Causing
Errors Misunderstanding (Comprehension Errors)	Unable to write down information and still not fully writing down the information in the question.	Can't understand the question well.
Transformation Errors	(1) Don't know the mathematical model. (2) Don't know the formula used.	(1) Don't know how to make a mathematical model yet. (2) Not sure what to use.
Process Skill Errors	(1) Incorrect calculation operation. (2) Don't know the steps to use	(1) Not yet aware of the appropriate solution steps. (2) Forgotten or not yet in accordance with the steps used. (3) Do not understand the steps to solve the problem.
Writing mistake Final Answer (Encoding Errors)	(1) Not careful when solving questions. (2) So the writing of the final answer and conclusion is wrong.	(1) Doesn't solve the problem. (2) The result of previous mistakes. (3) Rushing when solving questions.

To make it clearer, below are the results of calculating the percentage of errors experienced by students in solving trigonometry story problems based on the theory of test results given by students in terms of each type of error according to Newman's theory. The following is a table of the percentage of errors experienced by students.

Table 7. Percentage of Errors and Category of Error Types

Number Question	Error Type				
	1 (*Reading*)	2 (*Comprehension*)	3 (*Transformation*)	4 (*Process skill*)	5 (*Encoding*)
1	0	12	6	10	11
2	0	10	16	14	18
3	0	18	19	19	10
4	0	20	20	20	15
5	0	15	17	17	16
Amount	0	75	78	80	70
Percentage	0%	75%	78%	80%	70%

From table 7 it can be seen the percentage of errors made by students, where reading errors are 0%, understanding errors are 75%, transformation errors are 78%, process skills errors are 80%, and errors in writing final answers are 70%. The percentage of

students' total errors was 60.6%. Where process skills errors are the biggest mistakes made by students.

The factors that cause errors made by students in solving trigonometry story problems based on Newman's theory are as follows. First, comprehension errors, not being able to write down the information contained in the question, not writing the information contained in the question completely, not being able to understand the question well, not being able to understand what is known and not being able to understand what is being asked, forgetting to write down what is known and what is being asked, afraid of running out of time and being in a hurry so that you forget to write down what is known and what is being asked, confused and not understanding the sentences in the question. Second, transformation errors, not mastering enough material, not knowing the mathematical model, not knowing what formula to use to solve the problem, not being able to change the problem into the form of a mathematical model, not understanding how to make the mathematical model. Third, process skill errors, being in a hurry when solving, not being careful when solving problems, being confused about the formula used, being in a hurry when carrying out calculation operations, making mistakes in carrying out calculation operations, not knowing the steps involved. used to solve problems. Fourth, errors in writing the final answer (Encoding errors), as a result of previous errors, rushing to complete the question, forgetting to write the final answer because of haste, forgetting what was asked when writing the final answer, not being careful when completing the question, resulting in errors in write the final answer and conclusion, do not solve the problem.

This error model is relatively often a finding of analysis as in the results of research conducted (Usman et al., 2022). The factors causing errors made by students at MA Alkhairatt are lack of attention in the learning process, not liking mathematics lessons, difficulties in calculations, especially regarding negative operations. and positive, difficulty in applying formulas in solving problems, difficulty in making final conclusions, weak basic mathematical concepts, difficulty in algebraic calculations, and difficulty in solving word problems. Furthermore, in research (Setiana et al., 2021) on class XI students at one of the high schools in West Bandung Regency. Factors that cause errors made by students are lack of accuracy when solving problems and students' lack of understanding of the problems and concepts of three-variable linear equation systems.

4 CONCLUSION

The types of errors made by class skill errors), and errors in writing the final answer (Encoding errors). The biggest mistakes made by research subjects were process skill errors and errors in writing final answers (Encoding errors). The biggest errors were made at the process error stage, namely 80%. Meanwhile, the smallest errors made by students occurred at the final answer writing stage, namely 70%.

The factors that cause errors made by students in solving trigonometry story questions based on Newman's theory are: Causes of Comprehension Errors, including: (1) Students are unable to write down the information contained in the questions; (2) Incomplete writing of the information contained in the question; (3) Cannot understand the questions well; (4) Not able to understand what is known and unable to understand what is asked; (5) Forgetting to write down what is known and what is asked; (6) Fear of running out of time and being in a hurry so that you forget to write down what you know and what you ask; (7) Confused, don't understand the sentences in the question. Causes of Transformation Errors include: (1) Not mastering sufficient material; (2) Not knowing the mathematical model; (3) Not knowing what formula will be used to solve the problem; (4) Cannot change the problem into mathematical model form; (5) Not understanding how to create a mathematical model. Causes of Process Skill Errors include: (1) Rushing when solving questions; (2) Not being careful when solving problems, (3) Confused by the formula used; (4) Rushing when carrying out calculation operations; (5) Incorrectly performing square

calculation operations; (6) Don't know the steps that will be used to solve the problem. Causes of Final Answer Writing Errors (Encoding Errors), including: (1) Consequences of previous errors; (2) Rushing to complete the questions; (3) Forgot to write down the final answer because he was in a hurry; (4) Forgetting what was asked when writing the final answer; (5) Not being careful when solving questions, resulting in errors in writing final answers and conclusions; (6) Did not solve the problem.

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