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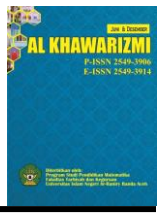

ANALYSIS OF HIGH SCHOOL STUDENTS' ERRORS IN SOLVING LINEAR PROGRAMMING STORY PROBLEMS BASED ON NEWMAN'S PROCEDURE

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Abstract

Error analysis based on Newman's procedure helps students understand the types of mistakes they make, thereby enabling them to anticipate and minimize these errors. This research aims to identify the errors high school students make in solving linear programming story problems and the factors causing these errors based on Newman's procedure. The study employs a qualitative approach with a descriptive method. The subjects consist of four students selected based on the frequency of errors. Data was collected through tests and interviews, then analyzed through data reduction, data presentation, and drawing conclusions. The results indicate that students make errors in understanding the problem, problem transformation, process skills, and final answer writing stages. The types of errors made by students based on mathematical objects include factual errors, conceptual errors, operational skill errors, and principle errors. The causes of these errors are attributed to rushing, physical conditions of students, neglecting steps deemed unimportant, and insufficient time provided to complete the tasks.

INTRODUCTION

Education is an effort undertaken to improve the quality of a nation. Similarly, in Indonesia, education functions to develop skills and shape the character and civilization of a dignified nation in order to enlighten the nation's life (Sagala, 2017:11). The national educational goals outlined in Article 3 of the Law (2008:5) aim to develop the potential of learners to become democratic, responsible, morally upright, healthy, knowledgeable, competent, creative, independent, and devout citizens who believe in and fear God Almighty.

Mathematics plays a crucial role in education and is taught at every level of schooling. Although not all everyday problems are mathematical in nature, mathematics helps address many daily issues. The goal of mathematics education is to produce a quality generation capable of adapting to modern times. Mathematics learning aims for students to understand and apply concepts and algorithms effectively in problem-solving. However, errors pose a significant obstacle to achieving this goal, as students must be able to solve mathematical problems without mistakes. The ability to solve mathematical problems is an indicator of students' skills in finding solutions to the problems they face (Kania & Arifin, 2018:2).

Based on the above, it can be concluded that in mathematical problem-solving, the main goal is not only the result but also the methods or strategies used to solve the problem systematically towards achieving the intended goal. One form of achievement expected by schools is improved student exam results and continuous school achievements, influenced in part by students' mathematics learning achievements. However, many students make mistakes in solving mathematical problems, primarily due to the breadth of the material, which must be fully understood by students to avoid errors, thus increasing the likelihood of students making mistakes in solving problems related to that material. One of the subjects in which students make the most mistakes is linear programming. Mastery of material in determining the solution area in inequalities and determining constraint functions in linear programming remains very low (National Examination Results Data for the Academic Year 2018/2019).

Linear programming material involves problem-solving through story problems reflecting real-life situations that connect mathematical concepts to students' reality. In practice, students often struggle to solve mathematical story problems, resulting in errors in various aspects such as understanding the problem, mathematical modeling, transformations, process skills, and final answer writing.

Newman's procedure can be used to identify errors that occur while students solve mathematical story problems. This analysis is conducted in five stages: reading errors, problem understanding, transformation, calculation, and final answer writing. Research indicates that the Newman procedure helps identify and understand errors made by students in mathematical story problems.

Dasmarwan's research results (2020:78) concluded that student errors include various stages: reading (4.89%), problem understanding (8.22%), transformation (12.67%), calculation (15.11%), and final answer writing (1.56%). Causes of errors include lack of interest in mathematics, low motivation, carelessness in answering questions, and fear of asking questions in class. Fitriatien's research (2019:63) also supports Newman's procedure in identifying student errors in solving mathematical story problems. Research results show student errors in careful reading, understanding problem information, rushed calculations, and negligence in final answer writing.

Based on these research results, information about students' errors in solving mathematics problems is crucial. Identifying student errors can assist students in solving mathematical story problems and enable teachers to design more effective learning strategies based on student error data. This aligns with Yani, Ikhsan, and Marwan's statement (2016) that errors made by students in solving mathematics problems can serve as information sources for teachers to design learning appropriate to students' thinking processes and characteristics. Furthermore, identifying these errors can reduce students' difficulties in solving mathematical story problems. This study aims to determine the errors made by high school students in solving linear programming story problems based on Newman's procedure and the factors causing high school students to make errors in solving linear programming story problems according to Newman's procedure.

RESEARCH METHOD

This research used a qualitative approach with descriptive research type, explaining what errors students made in solving linear programming story problems and the reasons students made these errors. In this study, the researcher collected and identified qualitative data based on interview results with research subjects selected from types of errors made by subjects based on Newman's procedure.

The research location was determined based on various considerations, including the presence of a case at the location being studied (Saputro, 2017:28). This study was conducted at State Senior High School 8 Banda Aceh over nine days. State Senior High School 8 Banda Aceh is located on Tgk. Chik Dipineung Raya Street, Kota Baru Subdistrict, Kuta Alam District, Banda Aceh City. Only one class was used in this study. Therefore, the subjects in this study were all students of class XI MIPA 5 at Senior High School 8 Banda Aceh who had studied linear programming material and were then given a test in the form of linear programming story problems (SCM_1).

The results of the students' work were then checked and categorized according to the number of errors based on Newman's procedure performed by the students. Then, four students were selected to be given a second-stage test (SCM_2)to analyze what errors the students made and the factors causing the students to make errors in solving these story problems based on Newman's procedure, starting with the students who made the most errors.

The instruments in this study consisted of main and supporting instruments. The main instrument was the researcher themselves responsible for designing, implementing, and analyzing the data. Supporting instruments included test sheets containing linear programming story problems as tools to analyze student errors, and interview guidelines designed according to error indicators based on Newman's procedure.

Next, data was collected through tests and interviews. The criteria for student errors according to Newman's procedure are as follows:

Table 1

Student Error Indicators According to Newman's Procedures (Sunardiningsih, 2019:43)

No	Newman's Procedure	Error Cause Criteria	Score	Yes/ No
1.	Reading	Students interpret the meaning of the requested word but **not accurately** according to the problem's request	2	
		Students interpret the meaning of the requested word but **less accurately**	1	
2.	Comprehension	Students write down the known information and what is asked but **not accurately** according to the problem's request	2	
		Students write down the known information and what is asked from the problem but **less accurately**	1	
3.	Problem ranspormation	Students **incorrectly** write down the model/formula to be used in solving the problem	2	
		Students **less accurately** write down the model/formula to be used in solving the problem	1	
4.	Process skill	Students can perform calculations but **not as intended** by the problem	2	
		Students can perform calculations but **less as intended** by the problem	1	
5.	Encoding	Students **inaccurately** write down the final answer	2	
		Students **less accurately** write down the final answer, which is the conclusion of the problem	1	
Note: Make a check mark (√) for Yes and a cross mark (×) for No.				

Next, the data was analyzed by identifying based on Newman's procedures, which involves pinpointing the errors made by students when solving mathematical problems. Miles and Huberman state that activities in qualitative data analysis are interactive and ongoing until saturation is reached, indicating that the data is sufficient (Satori & Komariah, 2017:218). The process of qualitative data analysis in this research was conducted through the following stages: data reduction, data presentation, and verification/conclusion drawing.

RESEARCH RESULTS AND DISCUSSION

Research Result

The research process involved administering a test consisting of linear programming problems presented as mathematical story problems. The purpose of the test given to the students was to identify errors in problem-solving and the reasons behind these errors. Errors made by students in solving the problems were identified from their written responses and further reinforced through interviews. Based on the students' written responses, errors in problem-solving were classified according to Newman's procedures: 1) errors in reading stage; 2) errors in understanding the problem stage; 3) errors in problem

transformation stage; 4) errors in process skills stage; and 5) errors in final answer writing stage. After the test was conducted, each student's answer sheet was evaluated by comparing their responses with the prepared answer keys. Following analysis and classification of the errors made by students, the researcher presented the results in tabular form for each problem number.

Below is the table presenting errors made by students based on Newman's procedures in the first test.

Tabel 2

Summary of Errors Made by Students in the First Test

Student initials / Question number	Errors Made by Students in the First Test										Total Errors
	T1		T2		T3		T4		T5		
	1	2	1	2	1	2	1	2	1	2	
S1	0	0	0	1	1	1	1	1	1	1	7
S2	0	0	1	1	1	0	2	2	1	2	**10**
S3	0	0	0	0	0	0	0	1	0	1	2
S4	0	0	0	0	0	1	0	1	1	1	4
S5	0	0	1	1	0	2	0	1	1	1	7
S6	0	0	0	0	0	0	0	1	1	1	3
S7	0	0	1	1	1	2	2	1	1	1	10
S8	0	0	2	0	1	2	2	2	2	1	**12**
S9	0	0	2	1	2	1	2	2	1	1	**12**
S10	0	0	1	1	1	1	2	0	1	1	8
S11	0	0	1	1	2	2	1	2	1	1	**11**
S12	0	0	1	1	0	1	0	0	1	1	5
S13	0	0	1	1	1	1	1	0	1	1	7
S14	0	0	0	1	1	1	1	1	1	1	7
S15	0	0	2	1	2	1	2	2	1	1	**11**
S16	0	0	1	0	1	2	1	1	1	1	8
S17	0	0	1	0	1	0	2	1	1	1	7
S18	0	0	0	0	1	0	0	0	0	0	1
S19	0	0	0	0	0	1	1	1	0	1	4
S20	0	0	1	1	2	1	2	2	1	1	**11**
S21	0	0	1	1	1	1	2	0	1	1	8
S22	0	0	1	0	1	1	1	0	1	1	6
S23	0	0	1	1	1	1	2	0	1	1	8
S24	0	0	1	1	1	0	1	1	1	1	7
S25	0	0	1	1	1	1	2	0	1	1	8
S26	0	0	1	0	1	1	1	0	1	1	6

Source: Errors Made by Students of XI MIPA 5

Explanation:
T1: First stage (reading the problem)
T2: Second stage (understanding the problem)
T3: Third stage (transforming the problem)
T4: Fourth stage (process skills)
T5: Fifth stage (writing the final answer)

Based on Table 2 above, it can be seen that the students who made mistakes in solving the problems in the first test are subjects S8, S9, S11, S15, S20, and S2. S8 and S9 made a total of 12 mistakes together; S11, S15, and S20 made a total of 11 mistakes; and S2 made 10 mistakes. Based on these errors, subjects S8, S9, S11, and S2 were selected, while S15 and S20 could not be selected even though they had one mistake more than S2. This is because S15 and S20 are unwilling to participate in interviews and are difficult to communicate with. Interview data will be used as a benchmark to identify the reasons for the mistakes made by students in solving mathematical story problems related to linear programming materials.

Discussion

Errors Made by High School Students in Solving Linear Programming Story Problems Based on Newman's Procedures

The errors made by students occur in the stages of problem comprehension, problem transformation, process skills, and final answer writing. The first stage, reading the problem, which is the initial step in Newman's procedure, shows that all subjects did not make errors because they were able to read each word and symbol in the problem clearly without any mispronunciations. This aligns with Clement's view that reading errors occur when students are unable to read words or symbols in the given problem (Susilowati & Ratu, 2018:14).

In the second stage, problem comprehension, subjects S9, S8, S2, and S11 made errors in this stage. They failed to write down the known information and the information asked in the problem using their own language, and they did not understand the meaning of the informational sentences in the problem. This is consistent with Ponoharjo, Utami, and Aulia (2019:18), who state that comprehension errors occur when subjects cannot write down known information or incompletely write down the information in the problem, and fail to write down the information asked on the answer sheet. The type of error that occurred in this stage is based on mathematical objects and is factual errors because the subjects did not write down the units of the numbers known from the problem. Nurfalah and Zanthy (2020:36) state that factual errors include errors in writing various signs for arithmetic operations, errors in writing mathematical symbols, and errors in writing units.

Additionally, in the problem comprehension stage, there are careless errors where subjects mistakenly wrote the value 8 instead of 6, as evidenced by interview results.

P01T1 : Okay, why did you write in the table that you mixed 8 kg of espresso coffee into nano coffee?
S801T1 : It was a mistake in yesterday's writing, it should have been 6 kg.

It appears that subject S8 made a careless mistake by incorrectly writing 8 instead of 6. This is consistent with White (Singh, 2010:267), who states that careless errors are

detected when students can still obtain the correct answer during interviews despite arriving at the wrong solution while working on test problems.

In the third stage, problem transformation, subjects S9, S8, S2, and S11 made errors. During this stage, they made mistakes in mathematical modeling, the use of inequality signs, and incomplete mathematical model writing. Singh mentions that errors in problem transformation occur when students fail to identify the operations or mathematical models to be used in solving the problem (Singh, 2010:267).

The types of errors include conceptual errors and factual errors. Conceptual errors occur because subjects incorrectly applied the concept of inequality between two variables used in linear programming, misplaced known data from the problem into the table correctly, and incorrectly wrote the mathematical model for the problem without understanding the concepts of maximum and minimum. Factual errors occur when subjects incorrectly write coefficients of the mathematical model. This aligns with Nurfalah and Zanthy (2020:34), who state that factual errors include mistakes in writing various signs for arithmetic operations, errors in writing mathematical symbols, and errors in writing units.

In the fourth stage, process skills, all four subjects made errors. They made mistakes in solving inequalities, including errors in drawing graphs, determining corner points, and calculating values in the objective function. This is consistent with Jami, Murniasih, and Yuwono, who state that skill errors occur when students cannot follow the algorithmic process to solve problems even though they can correctly state the formula or cannot execute procedures correctly even though they can determine the mathematical operations to be used correctly (Jami, 2020:34).

The types of errors include conceptual errors, skill (operation) errors, and principle errors. Conceptual errors occur when subjects cannot draw graphs correctly, in other words, they do not understand the concept of graph drawing. Skill (operation) errors occur when subjects make mistakes in operating the numbers written down. Principle errors occur when subjects cannot determine the correct corner points to solve the problem to find its optimal value. This is in line with Fitria (2013:8), who states that conceptual errors occur when students misunderstand the basic concepts in test problems. Skill (operation) errors occur when students cannot use operational rules correctly, and principle errors occur when there are mistakes in applying principles found in teaching materials.

Furthermore, in the fifth stage, final answer writing, all subjects made mistakes. Subjects made errors such as not writing conclusions and final answers to the problem asked. This is in agreement with Singh, who states that errors in writing final answers occur when students cannot write the final answer according to the question's instructions (Singh, 2010:266).

Factors Causing Students to Make Errors

The errors in Newman's stages committed by the subjects primarily occurred during the problem comprehension stage. The reasons students made errors in this stage include being unaccustomed to writing down known information and the information asked on the answer sheet because they feel it's unnecessary, not understanding the meanings of

words/sentences in the problem, forgetting to write them down due to rushing to answer the problem, and the physical condition of the students being less than optimal.

The causes of errors in the next stage, problem transformation, include being careless in understanding the problem by not paying clear attention to the units of each value, not fully understanding the overall meaning of the words in the problem, forgetting previous material which leads to mistakes in this stage, and students being less skilled in creating mathematical models due to infrequent practice.

Regarding errors in the process skills stage, students make mistakes due to errors made in the previous stages, which consequently lead to errors in this stage as well. Additionally, the lack of direct learning conducted by teachers at school due to COVID-19, which requires students to study independently at home, contributes to students' lack of skills in solving problems.

In the final stage of Newman's procedure, writing the final answer, almost all students make mistakes. The reasons for this include errors made by students in the previous stages, which lead to incorrect results, students neglecting to write conclusions for the problem because they feel it's unnecessary or they rush through, and spending too much time thinking about the solution, causing insufficient time for completing the final answer stage even though ample time was provided.

Overall, the causes of students making errors include being careless due to rushing, physical conditions of students being less than optimal, lack of skill in creating graphs due to insufficient practice, lack of direct explanations from teachers due to COVID-19, neglecting steps they deem unimportant which leads to errors, insufficient time provided for students to complete the problems, and errors from previous stages leading to errors in subsequent stages. This aligns with Sari and Rejeki (2021:9), who state that the causes of student errors include being careless in problem-solving, rushing through tasks, not being accustomed to writing complete solutions, lack of understanding or studying the material, insufficient practice, and misunderstanding the problem.

CONCLUSION

Based on the results of the research and discussion, the errors and their causes based on the Newman procedure carried out by the students can be summarized as follows:

ERROR

Errors in the understanding stage: factual errors and careless mistakes. Errors in the problem transformation stage: factual errors and conceptual errors. Errors in the process skills stage: conceptual errors, operational skill errors, and principle errors. Errors in the final answer writing stage: students incorrectly write conclusions and final answers to the problems posed in the questions.

CAUSES OF ERRORS

In the understanding stage, students are not accustomed to writing down the known information and the information asked on the answer sheet because they feel it is

unnecessary and are in a rush. They also do not understand the meaning of words/sentences in the problem. In the problem transformation stage, students are not careful in understanding the problem by not clearly paying attention to the units of each value, not understanding the overall meaning of words in the problem, and forgetting prerequisite materials, resulting in errors. Moreover, students are not skilled in creating mathematical models because they do not practice solving problems frequently.

In the process skills stage, errors made by students in the preceding stages also lead to errors in this stage. Additionally, direct learning opportunities provided by teachers in schools were limited due to COVID-19, forcing students to learn independently at home, which further reduced students' skills in problem solving.

In the final answer writing stage, errors made in previous stages result in incorrect outcomes. Students neglect writing conclusions for the problem, feeling it is unnecessary and rushing, or spending too much time thinking about the solution, leading to insufficient time to write the final answer to the problem.

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