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Analysis of Students' Errors in Solving Linear Program Questions

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ABSTRACT

This study aims to analyze the errors of class X SMA students on linear program material. The method applied is the qualitative description method. Purposive sampling was implemented in this study, and the participants were 30 students from class X MIA SMAN 5 Tapung. The types of errors analyzed are based on Nasution's theory, which states that there are three types of errors: conceptual errors, procedural errors, and computational errors. The test questions are given in the form of 7 description questions. The results of the analysis of student answers along with the analysis of interviews, errors in calculations occur because students are not careful in calculating and entering numbers into the formula. Therefore only 8 students whose scores exceed the standard score of 70. Based on the results of the analysis of student answers, it can be concluded that, students' errors in solving linear program questions are in conceptual errors where students do not understand the implied meaning of the questions; procedural and computational errors where students are not able to carry out the procedures or steps that will be used to solve the problems, do not know the arithmetic operations that will be used to solve the problems and do not write down the final results according to the procedures or steps applied.

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INTRODUCTION

Education is a deliberate and well-thought-out effort to create a learning environment and learning process in which students actively develop their potential for spiritual-religious strength, self-control, personality, intelligence, noble character, and skills required by themselves, society, nation, and state. The goal of national education is to educate and develop Indonesian people as a whole, namely people who believe in God Almighty and have noble character, knowledge and skills, physical and spiritual health, a strong and independent personality, and a sense of social responsibility and nationality [1].

Because of individual interactions with their environment, learning is a complex process that occurs to everyone and lasts a lifetime. Learning, according to [2], is a process of change, i.e., changes in behavior as a result of interactions with the environment in order to meet daily needs. All aspects of behavior will change as a result of these changes. As a result, learning is a process for changing one's behavior for the better. Learning is more than just memorization; it is a mental process that takes place in a person. The goal of the learning activity is for students to gain new knowledge that they can use to solve problems in their daily lives. Learning outcomes are the name for this type of capital.

Learning outcomes are changes or additions to knowledge that are characterized by increased creativity, comprehension, and improved student attitudes, among other things. According to [3], learning results in a change in behavior in the learner, such as going from not knowing to knowing

and from not understanding to understanding. These are the learning outcomes that teachers hope to see. To obtain these learning outcomes, it is necessary to conduct an evaluation that will provide information to the teacher about the students' abilities in the subject matter, one of which is mathematics, which is one of the fields of study studied in high school.

One sign that there are errors in the math problem-solving process is low learning achievement. The existence of these errors is partly due to students' lack of understanding of the concept of learning material, their lack of understanding of the purpose of learning, and their lack of inclination and encouragement to learn so that they are lazy to relearn learning material. This is in line with [4], who argue that mathematics has an abstract and scientific object that necessitates the ability to think logically, systematically, and critically, and for aforementioned reasons students have more difficulty understanding mathematics learning material than in other subjects.

Mathematics is a crucial subject that is taught in schools. This is because mathematics can help students develop critical thinking skills by allowing them to analyze problems critically. According to the Ministry of Education, the general goal of mathematics in elementary schools is to prepare students to face changes in an ever-changing world by teaching them to act logically, rationally, and critically, carefully, honestly, effectively and efficiently. Meanwhile, the purpose of mathematics in elementary schools is to develop and develop numeracy skills (the ability to use numbers) as a tool in everyday life. Therefore, students must be well-taught in the field of mathematics studies. It is hoped that the information provided will be useful to the students. The field of mathematics taught in elementary schools contains a wide range of subject matter that is ready to be taught, because if it is not taught properly, many errors will occur later when working on math problems.

Efforts to develop students' potential can be constructed through the mathematics learning process, which entails putting forward exact, correct, and direct knowledge to the target in order to form thinking discipline and train students to think simply, clearly, precisely, and quickly. Thus, mathematics subjects should be taught to all students at all levels of education in order to equip them with the skills to think logically, analytically, systematically, critically, and creatively, as well as the ability to collaborate. Furthermore, mathematics subjects are designed to instill in students a mindset that recognizes the value of mathematics in everyday life, such as curiosity, attention, and interest in learning mathematics, as well as resilience and confidence in problem solving.

Mathematics is regarded as the foundational science in a variety of fields. because mathematics is the foundation for all other sciences, particularly the advancement of science and technology Mathematics, as one of the subjects taught in schools, plays a significant role in the development of students' ability to communicate with symbols and sharpness of reasoning, allowing them to clarify and solve problems that arise in everyday life. We can use mathematics to think more logically, critically, and creatively.

Mathematics, according to [5], is the science of determining the sizes, shapes, structures, patterns, and relationships of objects and phenomena in the universe, as well as logical reasoning based on a deductive mindset. Where mathematics refers to the process of calculating numbers that are a part of everyday life. Mathematics aids in the precise prediction of various ideas and conclusions, as well as the discussion of space and form issues. To put it another way, mathematics is the queen of knowledge, which means that all science must be related to mathematics in some way, even if not directly.

It is unfortunate, however, that mathematics is regarded as a difficult subject for students. This is understandable because mathematics learning is closely linked to concepts, rules, or symbols that students find difficult to comprehend, resulting in a lack of mathematical understanding among

students. According to [6], mathematics teachers have a tendency to undervalue students' mathematical thinking skills in learning, particularly higher-order thinking skills. The teacher only teaches mathematical formulas, which the students are then expected to memorize in order to apply them to problems. Students struggle to solve math problems as a result of this, which leads to errors. The Linear Program material is one of the mathematics lessons taught and studied by high school students.

The purpose of evaluating learning is to determine the effectiveness and efficiency of the learning system, both in terms of objectives, materials, methods, media, learning resources, the environment, and the assessment system itself, according to [7]. Educational institutions frequently use tests and non-tests to assess student learning.

A good test should be considered for its practicality, reliability, validity, objectivity, and economics, according to [8]. If a test is practical, easy to administer, and includes clear instructions, it is said to have high practicality. Validity refers to a test's ability to precisely measure what should be measured. As a result, it can be concluded that a valid test is one that can accurately measure an object. When a test is repeated many times and shows consistent or permanent results, it is said to be reliable. If a test is practical, it is said to have high practicality. In addition to considering validity and reliability, the questions that will be tested on students must be thoroughly examined first. According to [9] opinion, the evaluator can determine the level of difficulty of the items and the degree of differentiation by analyzing the questions.

Students are given test questions to determine their abilities in relation to the material they have been given. However, the student's test results were not always satisfactory, indicating that the students were not always correct in their answers and frequently made mistakes. Students are said to have made mistakes if they were wrong in solving the questions. This error can be detected after the student has completed, or not completed, the tested questions. Students' learning mistakes must be completely resolved right away, because if they are allowed to continue, the students will assume that they are correct, causing the mistakes to be repeated. This is in accordance with the law because, according to [10], if a child's mistakes are left unattended without a proper explanation from the teacher, the child may believe it is correct and repeat it. Because there is a chance that the concept that the student holds is the correct answer, this assumption will result in answers that remain incorrect when the child takes the test. Students' abilities, such as their understanding of definitions, theorems, properties, formulas, and the teaching process, cause them to make mistakes when solving math problems. Aside from that, it can be caused by a lack of mastery of the material, carelessness, and a student's readiness to learn. When it comes to student errors, there are a number of factors that influence students to make mistakes when solving math problems, namely factors that affect the mathematical process and learning outcomes.

According to observation, student achievement in the Linear Program material is still unsatisfactory. The achievement of learning mathematics in the Linear Program material is still very low in class X MIA at SMA Negeri 5 Tapung, Kampar district for the 2020/2021 academic year. The average score on daily tests of the Linear Program material is only 36.2 % with the passing grade (KKM) of 70. This indicates that the average math learning achievement score is still below the KKM. This is because students encounter numerous difficulties when working on math problems, particularly in the subject of trigonometry, resulting in frequent errors. The number of errors that students make while working on the questions can indicate how well they understand the material. What types of errors were made and what factors caused the errors made by students in solving math problems on trigonometric material are the issues that arise. As a result, researchers are encouraged

to investigate and analyze student errors in the Linear Program material, particularly the two-variable linear program sub-subject.

The difficulty is derived from the word "difficult," which means "very difficult or difficult," according to the Indonesia Dictionary [11]. Meanwhile, a difficult situation or something difficult, or in other words, a condition or situation that is almost beyond one's ability to face and requires a great deal of effort to overcome, is referred to as difficulty. Errors, according to [12], are defined as deviations from the correct path that are systematic, consistent, and incidental in some areas. As a result, an error is defined as something that does not follow established procedures or rules in a systematic, consistent, and unintentional manner. Student error is a symptom of a disease, which could be a serious illness or a combination of illnesses [13].

Mistakes, according to [14], are the result of inappropriate actions that deviate from established rules, norms, or systems. The researcher's definition of error in this study is an error that is immediately visible on the results of students' written work in solving math problems, such as concept errors, procedural errors, and computational errors.

There are several types of mistakes that students can make when learning mathematics, including concept and operation errors. Meanwhile, according to [15], common mistakes made by children struggling with mathematics include a lack of understanding of symbols, place values, calculations, process misuse, and illegible writing. Language interpretation errors, concept errors, procedural errors, technical errors, and drawing conclusions, according to [16], are the four types of errors. Meanwhile, translation errors, concept errors, strategy errors, systematic errors, sign errors, and calculation errors are among the mistakes made by students when solving math problems, according to [17].

According to the above description, errors in problem solving are deviations made by students who do not follow predetermined rules or procedures for settlement steps. It is necessary to examine students' efforts in solving mathematical problems in order to determine where they made errors. Nasution's theory divides the three types of errors into three categories [18]:

1. Conceptual errors are errors in understanding mathematical concepts that are prerequisites and concepts that have been taught, namely Linear Programs
2. Procedural errors are errors in relating some facts or concepts in solving linear programming problems.
3. Computational errors include miscalculation and writing errors in solving linear programs.

The NEA (Newman's Error Analysis) is one of the tools that can be used, according to Anne Newman. According to [19], NEA is widely used and applied in a variety of countries as a tool for determining the causes of various types of student errors in solving math problems. Newman's five types of errors are also explained by [20] as follows:

1. Reading Error
   If a student cannot read the keywords or symbols written in the problem, it will be classified as a reading error, preventing it from being processed further to correct problem solving.
2. Comprehension Error
   Students can read all of the words in the question, but they don't understand the meaning of all of them, making it impossible for them to proceed to correct problem solving.
3. Transformation Error
   The student comprehends the questions but is unable to identify the operations or sequence of operations needed to solve the problem.
4. Process Skills Error

Students can recognize appropriate operations but lack the knowledge of how to carry out these operations correctly.

5. Encoding Error
   Students can solve a problem correctly, but they can't express it in the proper written form.

Meanwhile, according to Soedjadi in [21], the errors that have been made by students include:

1. Errors in procedure, specifically when using algorithms.
2. Errors in organizing data, for example errors in writing down what is known, what is asked of the questions
3. Errors in sorting, grouping and presenting data
4. Errors in the use of symbols, tables, and graphics that contain information
5. Errors in mathematical manipulation, characteristics in solving problems.
6. Errors in drawing conclusions

However, in this study, researchers used the types of errors according to Nasution's theory. The following are the errors made by students when solving problems involving the Liner program in the problem of linear inequality in the three causal factors:

1. Errors in receiving information
   a. Errors in writing down what is known
   b. Errors in determining what is asked
2. Errors related to the Linear Program concept in determining maximum and minimum value
   a. Errors in using and applying the linear inequality signs.
   b. Error in determining the maximum value.
   c. Error in determining the minimum value.
   d. Errors in drawing graphics.
3. Errors in counting

Based on the results of the analysis of student answers, which was strengthened by the results of interviews, many students made arithmetic errors and entered values into the formula caused by the lack of accuracy of these students.

METHODS

Students in class X MIA SMAN 5 TAPUNG in the odd semester of the 2020/2021 academic year were selected to be the subjects of this study, which included a total of 30 students. The goal of this study is to look at how students solve problems in the Linear Program course that involve the explanation of mathematical subjects.

This is a descriptive qualitative research. Descriptive research, according to [7], is research that is used to describe and answer the problems of a current phenomenon or event. Qualitative research, according to [22], is research that aims to understand phenomena experienced by research subjects such as behavior, perception, motivation, and so on. Any errors that students make in solving math problems related to linear programs are described using a descriptive approach. Furthermore, a qualitative approach is used to determine where students' errors occur; thus, qualitative descriptive is a representative picture of student errors in comprehending math questions.

The process of qualitative data analysis activities in this study was carried out with the following steps:

1. Correcting answers of students.
2. Counting the number of students who answered correctly and incorrectly for each question.
3. Describing several errors of students for each type of error.

4. Calculating the percentage of the number of students for each type of error.
5. Describing types of errors for each question.

The research procedure carried out in this study includes three stages, namely the preparation stage, the implementation stage and the data analysis stage. Each stage will be described in the following table:

Table 1. The Research Procedure Stages

First stage Preparation stage	Second stage Implementation stage	Last stage Analysis stage
1. Searching for school and asking for permission to the mathematics teacher. 2. Constructing the research instrument. 3. Making deal with the mathematics teacher regarding the time to be used for the research **4.** Validating the instrument in form of test items.	The implementation was conducted on Tuesday, November 16 2020.	The obtained data is then analyzed according to analysis data technique.

According to the Linear Program material indicators described in the following table and error analysis indicators used in the study, the researcher used a test with seven items to collect data

Table 2. Linear Program Material Indicators

Basic Competencies	
Knowledge	**Skills**
3.2. Explaining a two-variable linear program and its method of solving it using contextual problems.	4.2. Resolving contextual problems which deals with a two-variable linear program.

Competency Achievement Indicators	
Knowledge	**Skills**
• Explaining the definition of two-variables linear program. • Explaining a system of linear two-variables inequalities. • Explaining the optimum value of the objective function. • Explaining the application of a linear • program two variables in solving the problem.	• Solving related problems with a two-variable linear program. • Presenting problem solving related to two-variable linear programming.

Table 3. The Blueprint of Daily Examination Questions

Standard Competency	Subject matter	Competency Achievement Indicators	Question Indicator	Number of Item
3.2. Describing a two-variable linear program and its method of solving it using contextual problems	Two-variable linear inequality	• Explaining the meaning linear program two variable • Describing the system linear inequality two variables • Describing values optimum function objective • Describing	• Students can determine the linear inequality system from an image. • Students can determine the set of solutions from a linear inequality system. • Student can complete the minimum value of a	1 & 2 3 4

	application linear program two variable in solve the problem	function and objective if it is known the completion area of an image. • Students can determine the minimum fee to pay for a contextual problem.	5,6,7

Before being given to students, previously carried out several tests on the question such as validity, reliability, level of difficulty, and discriminating power.

1. Item validity

To measure the validity of the items or the validity of the test items used product moment correlation with the following formula:

$$r_{xy} = \frac{N(\sum XY) - (\sum X)(\sum Y)}{\sqrt{\{N\sum X^2 - (\sum(X)^2\}\{N\sum Y^2 - (\sum Y)^2\}}}$$

Information:

r_{xy} : correlation coefficient of an item

N : number of respondent subject

X : score of an item

Y : total score

After each item is calculated the value of the correlation coefficient with the total score, then the next step is to calculate the t-test with the following formula:

$$t_{count} = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

Information:

t_{count} : value of t count

r : correlation coefficient of r count

n : number of respondents

The value is obtained based on the table of t values at the significant level = 5% or 0.05 for the two-tailed test and the degrees of freedom dk = n - 2. The decision rules used are:

a. If $t_{count} \geq t_{table}$, it means valid

b. If $t_{count} < t_{table}$, it means invalid

Table 4. Results of Item Validity

Number of Item	Correlation Coefficient of t_{count}	Value of t_{count}	Value of t_{count}	Decision
1	0,363	0,373	0,361	Valid
2	0,618	0,373	0,361	Valid
3	0,622	3,949	0,361	Valid
4	0,284	1,458	0,361	Invalid
5	0,131	1,552	0,361	Invalid
6	0,724	1,747	0,361	Valid
7	0,573	5,239	0,361	Valid

2. Item reliability

A test is said to be reliable if the testees' scores or values are consistent, regardless of when, where, or by whom the test is administered, reviewed, or scored. The researcher employs the Alpha

formula in this study because it may be used to determine the reliability of instruments with scores other than 1 and 0, such as a questionnaire or a question form description. The procedure is as follows:

a. Calculating the score variance of each item

$$S_i^2 = \frac{\sum X_i^2 - (\sum X_i)^2}{N}$$

b. Calculating the total variance of the item's overall score

$$\sum S_i^2 = S_1^2 + S_2^2 + S_3^2 + S_4^2 + S_5^2 + S_6^2 + S_7^2$$

c. Calculating the total S_t^2 $s_t^2 = \frac{\sum X_t^2 - \frac{(\sum X_t)^2}{N}}{N-1}$

d. Calculating the test reliability coefficient

$$r_{11} = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum X_i^2}{S_t^2}\right)$$

Information:

S_i^2 : item score variance

X_i : item score

X_t : total score

N : number of testees

S_t^2 : total variance

n : number of item test in the question test

r_{11} : test reliability coefficient

The interpretation of the test reliability coefficient uses the following guidelines:

Table 5. Reliability Coefficient Classification

r value	Interpretation
0,80 ≤ *r* ≤ 1,00	Very high
0,60 ≤ *r* ≤ 0,80	High
0,40 ≤ *r* ≤ 0,60	Medium
0,20 ≤ *r* ≤ 0,40	Low
0,00 ≤ *r* ≤ 0,20	Very low

Based on the results of the test reliability calculation, the test reliability coefficient (r_{11}) is 0.757. If the results of r_{11} are consulted with the value of the Product Moment r table with dk = n – 2 = 30 - 2 = 28, significant 5% then obtained 0.3610. The decisions are based on the following rules:

a. If it means reliable

b. If it means not reliable

With a reliability coefficient (r_{11}) of 0.757, it can be stated that the research instrument is in the form of a description test by presenting which 7 items. The test which was followed by 30 students had high test reliability.

3. Level of difficulty

The level of difficulty or difficulty level of each item can be used to determine the quality of a question. The number of the item difficulty index can be used to determine the value of difficulty (difficulty index). The following is the formula for calculating the difficulty index:

$$P = \frac{(SA + SB) - T\,(S_{min})}{T\,(S_{max} - S_{min})}$$

Information:

P : difficulty level
SA : sum of upper group score
SB : sum of lower group score
T : total of the student
S_{max} : maximum score
S_{min} : score minimum
The interpretation of the level of difficulty of the questions can be seen in the following table:

Table 6. Difficulty Level Interpretation

P value	Interpretation
P = 0,00	very difficult
0,00 < P ≤ 0,30	Hard
0,30 < P ≤ 0,70	Medium
0,70 < P ≤ 1,00	Easy
P = 1,00	Very easy

The results of the calculation of the difficulty level of the questions are as follows:

Table 7. Calculation Results of The Difficulty Level

Number of Item	Difficulty Level	Criteria
1	0,93	Easy
2	0,87	Easy
3	0,20	Hard
4	0.17	Hard
5	0,93	Easy
6	0,83	Easy
7	0.13	Hard

According to the calculations, there were 4 question items categorized to have easy difficulty level and 3 question items categorized to have hard difficulty level among the 7 items tested.

4. Discrimination power

The ability of a test item to distinguish between high-ability and low-ability testees is referred to as discrimination power. Discrimination power is represented by the letter DP and is determined by the value of the item discrimination index number (discrimination power). The following formula can be used to calculate a test item's distinguishing power:

$$DP = \frac{SA-SB}{\frac{1}{2}T\,(S_{max}-S_{min})}$$

DP : Discrimination Power
SA : sum of upper group score
SB : sum of lower group score
T : total of the student
S_{max} : maximum score
S_{min} : score minimum
The classification of discrimination power is as follows:

Table 8. Discrimination Power Classification

Item Discrimination Power	Criteria
DP ≤ *0*,00	Very Bad
0,00 < DP ≤ 0,20	Bad
0,20 < DP ≤ 0,40	Enough
0,40 < DP ≤ 0,70	Good
0,70 < DP ≤ 1,00	Very Good

The following are the findings of the distinguishing power calculation:

Table 9. Calculation Result of Discrimination Power

Number of Item	Discrimination Power	Criteria
1	0,125	Very Bad
2	0,375	Enough
3	0,625	Very Good
4	0,375	Enough
5	0,125	Very Bad
6	0,625	Very Bad
7	0,50	Good

RESULTS AND DISCUSSION

The next action is to assess the answers after the students have completed the test questions. There are various forms of errors in solving issues in the form of Linear Programs based on the outcomes of the data obtained. Analysis of Student Error Location According to Nasution:

Table 10. Recapitulation table of student scores

Score	Number of students
85	4
70	4
56	16
43	3
28	2
14	1

From the table 10, it was found that 8 students reached the KKM score of 70

Table 11. Number of Correct and Incorrect Answer of Each Question

Question Number	Number of students answered correctly	Percentage	The number of students answered incorrectly	Percentage
1	28	93,3 %	2	6,6 %
2	26	86,6 %	4	13,3 %
3	6	20 %	24	80 %
4	5	16,6 %	25	83,3 %
5	28	93,3 %	2	6,6 %
6	25	83,3 %	5	16,6 %
7	4	13,3 %	26	86,6 %

Table 4 shows that students made mistakes on each item. Students made the most mistakes, namely in question number 3, number 4 and number 7. students answered incorrectly on questions 3, 4, and 7 with the number of incorrect students being 24 (80%), 25 (83.3%) and 26 (86.6%) respectively. The following pictures represent the students' common errors.

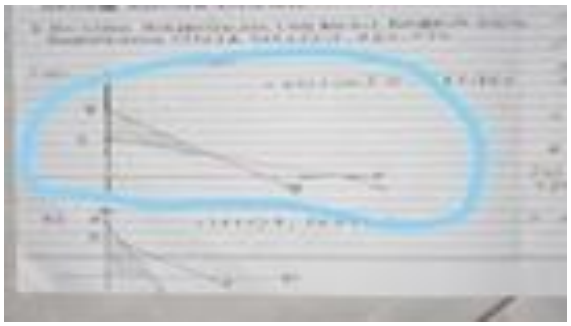

Figure 1. Student's Error in Question Number 1

In question number 1, there are 2 students making procedural errors with a percentage of 6.6%. This error occurs because students did not clearly specify how the process explained the results.

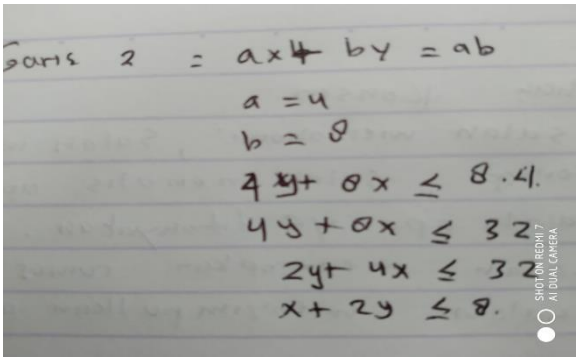

Figure 2. Student's Error in Question Number 2

In question number 2, there are 4 students making a conceptual error with a percentage of 13.3%. This error occurs because students did not know how to apply positive or negative signs to numbers.

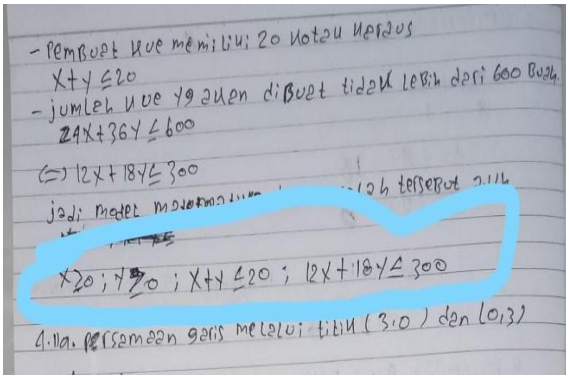

Figure 3. Student's Error in Question Number 3

In question number 3, there are 24 students who make errors in computing with a percentage of 80%. This error occurs because students had not simplified the final value of the inequality whose value is big.

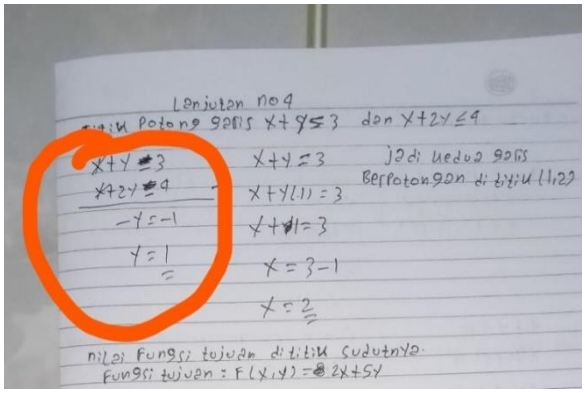

Figure 4. Student's Error in Question Number 4

In question number 4, there are 25 students who make a conceptual error with a percentage of 83.3%. The error occurred because the student wrote the wrong positive negative sign.

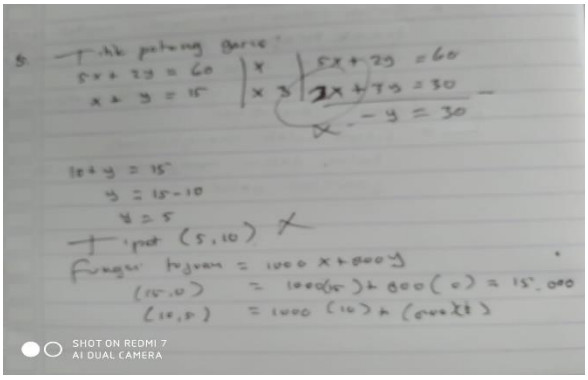

Figure 5. Student's Error in Question Number 5

In question number 5, there are 2 students who make computational errors with a percentage of 6.6%. This error occurred because the student miscalculated the multiplication result.

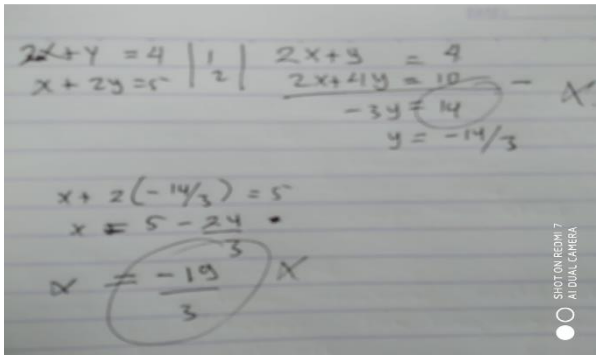

Figure 6. Student's Error in Question Number 6

In question no. 6, there are 5 students who make computational errors with a percentage of 16.6%. This error occurs because the student miscalculated in the subtraction operation.

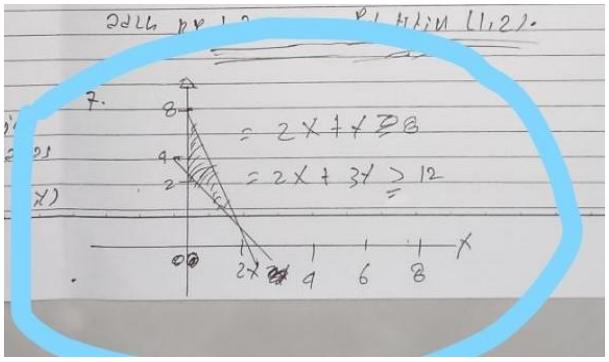

Figure 7. Student's Error in Question Number 7

In question number 7, there were 26 students who made procedural errors with a percentage of 86.6%. This error occurs because although many students are able to understand the problem to be solved, students are not able to draw properly and correctly.

CONCLUSIONS AND SUGGESTIONS

Based on the students' answers, it can be concluded that the students' errors in solving the Linear Program questions were reading errors, which resulted in incorrectly writing the meaning of the words requested. The term "misunderstanding" refers to a lack of understanding of the question's implicit meaning. Not knowing the arithmetic operation to use and being unable to create a mathematical model from the information presented is a transformation error. Not being able to carry out the procedures or steps that will be used to solve the questions, not knowing the arithmetic operations that will be used to solve the questions, and not being able to carry out the procedures or steps that will be used to solve the questions are all examples of process skills errors. The final answer error is when the final result is not written according to the procedure or steps used.

The solution to be able to minimize student errors in solving Linear Program questions is that students need to get reinforcement regarding their knowledge of mathematical symbols or terms, students need to be given an explanation using concrete or real props, students need to be trained to understand the problem in the problem as a whole, students need to get used to solving story problems mathematically and clearly, and the teacher should remind students to double-check their worksheets before submitting them.

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