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Analysis of Students' Errors in Solving Story Problems Based on Newman's Error Analysis (NEA) on the Subject Matter of Linear Program in View of Students' Mathematical Ability

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Abstract

This study aims to describe the types of errors of students in class XI SMA Negeri 1 Sirenja in solving story problems of linear program material based on *Newman's Error Analysis in terms of* mathematical ability. This type of research is qualitative research with a descriptive approach. The subjects in this study were based on the results of prerequisite tests with two-variable linear inequality material with consideration of students who made the most mistakes, were able to communicate well and recommendations from mathematics teachers with one student with high, medium and low mathematics abilities. Data collection techniques in this study were written tests and interviews in the form of one *essay* question and interview guidelines. The interview technique used was semi-structured conducted with selected students to ascertain the types of errors made in solving story problems. The results of this study show that the errors made by subjects with high mathematics ability (ST) made mistakes in writing the final answer *(encoding error)*. Errors made by subjects with moderate mathematics ability (SS) made errors in *process* skills *(process skill errors)*, and errors in writing the final answer *(encoding errors)*. Errors made by low ability subjects (SR) made errors in understanding the problem (*comprehension error), errors* in changing the problem into mathematical form *(transformation error)*, errors in process skills (*process skill error)*, and errors in writing the final answer (encoding error).

Keywords: error analysis, story problem, newman's error analysis, linear program, math ability

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INTRODUCTION

Education is a process to increase knowledge that can be obtained through the school environment, community and family. The government has made various efforts to improve the quality of education, including improving and refining the school curriculum, improving facilities and infrastructure, and formulating policies to develop national education according to the demands of science and technology (Muda, et al 2021). The subject that is often taught at every level of education in schools is mathematics.

Mathematics is a basic science that continues to develop both in terms of theory and application. Therefore, in the world of education mathematics is studied by all students starting from elementary school level to college level. This is corroborated by the opinion of Rusmana (2019) who argues that mathematics is an important tool for students as they face problems and challenges in personal, work, community, and scientific aspects of their lives. Mathematics is also one of the disciplines that underlie the development of modern technology (Jamal, 2018). Thus, it is important to teach students how to solve problems correctly, especially those that require the application of mathematics.

Mathematics story problems are mathematical problems that use a series of words or sentences in the form of a story and the context is related to everyday life (Diva & Purwaningrum, 2022). This is in line with research conducted by Jumiati & Zanthy (2020) which states that story problems are considered difficult problems because students do not understand the material and cannot understand and identify the problems presented in story problems. Solving story problems compared to problems in the form of numbers, story problems tend to be more difficult (Sari et al. 2020). Difficulty in solving story problems can cause errors in solving these problems (Fitriatien, 2019).

The number of errors made by students in solving math problems needs to be a concern, errors that are often made by students in solving math story problems such as research conducted by Rismawati & Asnayani (2019) who wrote that errors in solving story problems include errors in reading problem commands, students do not understand the problem, students have difficulty converting problems into mathematical sentences, students make mistakes in arithmetic operations so that students' answers are wrong, and students make mistakes in converting the final results into contextual mathematical sentences or making conclusions.

The material in mathematics learning that is closely related to the form of story problems is linear program material. Linear program material is part of mathematics learning that learns how to plan an activity mathematically using linear inequalities. Linear programs are often used to solve problems in various fields of activity such as trade, agriculture, transportation and so on, so that with an increase in the ability of students to solve linear program problems it can be a good capital for the future of Indonesia.

Based on the results of interviews with mathematics teachers, the teacher said that these mistakes were made by many students, so that only 25% of students were correct in solving the story problem. This is in line with the results of research that revealed 14% of students made reading errors, 31% made comprehension errors, 41% transformation errors and 14% errors in process skills (Nikmah, et al. 2020). One of the efforts to reveal the types of errors made by students is through an error analysis process.

Analysis is the activity of understanding all the information in a case to find out what problems are happening, then deciding what to do immediately to get a solution or problem solving (Arfani, et al. 2021). Data analysis is also a systematic effort to find and organize records of observations, interviews, and others to improve the researcher's understanding of the case under study and present it as findings for others (Usman & Kristiawati, 2022). Meanwhile, errors in solving problems are deviations made by students in solving problems from what is considered correct or deviating from previously established procedures. In line with research conducted by Destiani, et al. (2022) wrote that students' errors in solving math problems are related to errors made by students when using and applying steps or procedures in solving math problems.

This error can occur due to several things such as students being sick, tense, and others. Errors also often occur in the learning process and need to get more attention. These student errors then become material for the teacher's evaluation of learning activities in order to correct the discrepancies that occur in students, the importance of analyzing errors made by students to find out the factors that cause these errors which can then be corrected and reduce the chances of mistakes being made later (Kamagi & Runtu, 2020).

Newman's Error Analysis (NEA) is one method designed as a simple diagnostic procedure in solving mathematical story problems. The types of errors made, namely (1) *reading* errors include students who are unable to read the words or symbols contained in the problem even the signs - *(*less), + (add), = (equal to), *x* and *y* variables as well as ≤ *(*less than equal to), ≥ (more than equal to) are read incorrectly or incorrectly. (2) *comprehension errors* include students not being able to know what problems to solve and not getting important information in the given problem. (3) *transformation* errors include students who fail to translate mathematical sentences into mathematical form and choose mathematical operations for completion. (4) *process skill* errors include errors made in the calculation or solution

process. (5) *encoding errors* include errors made by students when determining the final answer or not writing the final answer (Kalengkongan, 2021).

The choice of method using Newman error analysis is strengthened by supporting research such as research conducted by Simbolon, et al (2023) who got results in the form of errors in reading of 3.57%, errors in understanding of 14.29%, transformation errors of 55.71%, process skills errors of 46.43%, and errors in writing the final answer of 26.43%. Error analysis based on Newman's stages is considered suitable because this error analysis will reveal the types of errors made by students in solving story problems, especially in linear program material and the results of this study can certainly provide knowledge to students in an effort to improve and minimize errors in solving story problems on the subject of linear programs, students also better understand and understand linear program material.

This study aims to obtain a description of the research results in the form of written words or sentences regarding the types of student errors in solving story problems on linear program material based on *Newman's Error Analysis,* namely: *reading error*, *comprehension error*, *transformatin error*, *process skill error* and *encoding error*. Analysis of student errors on linear program material using Newman indicators in terms of *Adversity Quotient* (Hutami, et al 2020). This is in line with research conducted by Andriyani, (2018) which analyzes student errors in solving linear program story problems with subjects based on student cognitive styles. The percentage of errors in understanding the problem using Polya's indicators in solving Linear Program story problems with research subjects based on students' mathematical abilities (Fauziyah & Pujiastuti, 2020). Research conducted by Ayuningsih, et al. (2020) analyzed student errors using error analysis based on Kastolan with a research subject of four students who made the most mistakes.

Based on some previous research results, the researcher took the initiative to conduct research using *Newman's Error Analysis* as a means to reveal the types of student errors in solving story problems on linear program material with research subjects of students with high, medium and low mathematics abilities. This research is considered important because the results of this study will focus more on subjects with three different levels of mathematical ability.

METHOD

This type of research is qualitative research with a descriptive approach. The data obtained in this study came from the results of students' written tests in solving story problems on linear program material and the results of interviews with three students with high, medium and low mathematics abilities.

The instruments used in this study were written tests and interview guidelines. The questions were given in the form of descriptions. While the interview guideline contains a list of questions that will be asked to the research subject during the interview. The following forms of test instruments used in this study are presented in Table 1.

Table 1. List of test question instruments based on Newman's error types

Instrument	About
Test 1	Rani and Ratu run a small business, they work together to produce shirts and skirts. To complete 1 shirt, Rani and Ratu must work together for 1 hour. To complete 1 skirt, Rani must work 1 hour and Ratu must work 0.5 hours. Every day, Rani can only provide 7 hours of work, and Ratu only 5 hours. They want to make the same number of shirts and skirts. They can make a profit of Rp80,000 for each shirt and Rp60,000 for each skirt (Assume all blouses and skirts are sold out). a. Design the mathematical model. b. What is their maximum profit?

Instrument	About
Test 2	Ana and Ani work together to make a bouquet of flowers and a bouquet of dolls. To complete 1 bouquet of flowers, Ana and Ani must work together for 2 hours. To complete 1 doll bouquet, Ana has to work 2 hours and Ani has to work 1 hour. Every day, Ana is able to provide 5 hours of work, and Ani only 3 hours. They want to make the same number of flower bouquets and doll bouquets. They can make a profit of Rp80,000 for each flower bouquet and Rp50,000 for each doll bouquet (Assume all bouquets are sold out). a. Design the mathematical model. b. What is their maximum profit?

The data analysis used in this study refers to qualitative data analysis according to Miles & Huberman *in* Sugiyono (2015) carried out interactively through the process of data condensation (*Data Condensation)*, data presentation (*Data Display)* and *drawing and* verifying *conclusions*. This data analysis aims to reveal the types of errors made by students in solving linear program story problems based on *Newman's Error Analysis.* The following error analysis indicators based on *Newman's Error Analysis* modified from Mulyani, et al. (2019) are presented in Table 2.

Table 2. Indicators of error analysis based on *Newman's Error Analysis*

Newman's Error Analysis	Error Indicator
Reading Error	a. Students cannot read words, units or symbols correctly. As well as not being able to interpret words that are considered difficult to submit
Comprehension Error	a. Students do not write the information in the problem in the form of what is known and cannot explain what is implied in the problem. b. Students do not include important information in the problem such as what is asked because students cannot explain the meaning of the question question
Transformation Error	a. Students do not convert the information contained in the problem into a mathematical model or sentence and do not explain the process of change. b. Students convert the information contained in the problem into a mathematical model but inaccurately c. Students are wrong in choosing the operation used to solve the problem
Process Skill Error (Error in process performance)	a. Students are wrong in the correct mathematical rules or rules b. Students cannot continue the procedural process in solving the problem
Encoding Error (Error in writing the answer)	a. Students do not write the conclusion b. Students write conclusions that are not in accordance with the context of the problem

Testing the validity of data in this study using time triangulation. Time triangulation is done by checking data with the same source at different times or situations. If there is different information or answers given by the subject regarding the stage of solving the problem, then

the test is carried out again until it gets a consistent answer. If the answers given by the subject are consistent, then the data collection process is complete.

RESULTS AND DISCUSSION

The subjects in this study were one student each with high, medium and low math ability in class XI MIA 3 consisting of 26 students. The selection of research subjects was based on students who made the most mistakes, were able to communicate well and received recommendations from the mathematics teacher of SMA Negeri 1 Sirenja. The identification results based on these considerations and discussions with the mathematics teacher of class XI SMA Negeri 1 Sirenja, the subject with the code **ST** as a high ability subject, **SS** as a medium ability subject and **SR** as a low ability subject were selected.

ST Students' Error Analysis Based on *Newman's Error Analysis*

Based on ST's answer in Figure 1 in solving ST has written what is known in the problem, ST can make a mathematical model, ST can determine the intersection point of the mathematical model and make a graph and determine the solution area of the graph, ST has also made an appropriate solution but ST did not write a conclusion in his final answer.

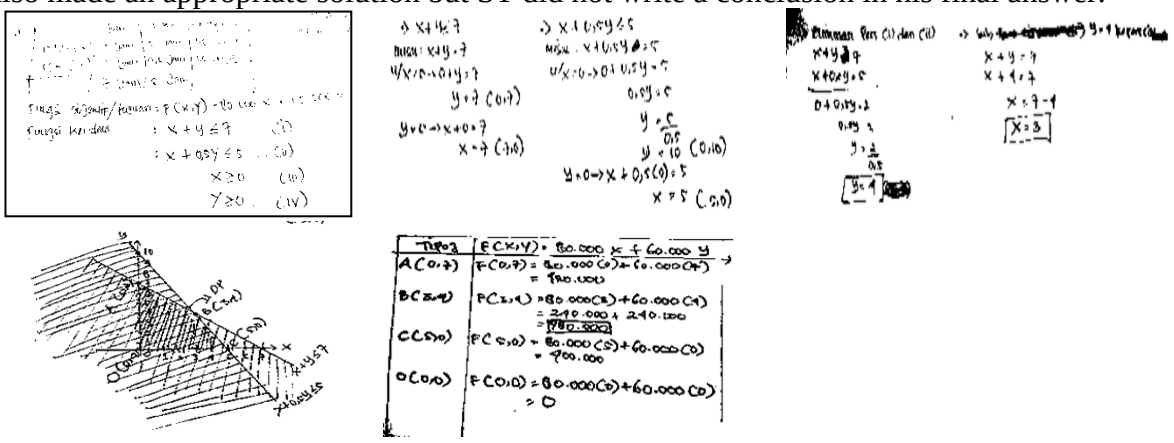

Figure 1. Results of ST Students' Answers

The researcher conducted an interview to obtain further information about the mistakes made by the subject. The following is an excerpt of the results of the researcher's interview with ST.

STT1075P : So, what is the maximum profit that can be obtained?
STT1076S : Rp. 480,000.00 (four hundred eighty thousand rupiah) kak.
STT1077P : Now that you know, then why don't you write the conclusion in your answer? (showing the answer sheet of Test 1)
STT1078S : Ohh hehehe, sorry sis I was in a hurry.

Based on the results of the interview above, the information obtained that ST made a mistake in writing the final answer or ST did not write a conclusion on his answer as evidenced in the excerpt of the interview STT1078S.

Based on the test and interview results, it is obtained: ST made an error in writing the final answer where ST can mention the final answer of the problem solving but ST did not write it down because ST worked in a hurry and was less careful besides that, ST also thought that his answer was correct. Based on *Newman's Error Analysis, the error* committed by ST is referred to as the type of final answer writing error *(Encoding Error).*

SS Students' Error Analysis Based on *Newman's Error Analysis*

Based on SS's answer in Figure 2. in the solution SS has written what is known in the problem, SS can make a mathematical model, SS can determine the intersection point of the mathematical model and make a graph but SS does not determine the solution area of the graph,

SS performs calculations using the elimination method but it is not correct where SS writes *x-x=1* which should be *x-x=0* and does not write the result of subtraction from *y-0.5y*, SS also does not continue his work so SS cannot determine the final answer and does not write the conclusion of the answer.

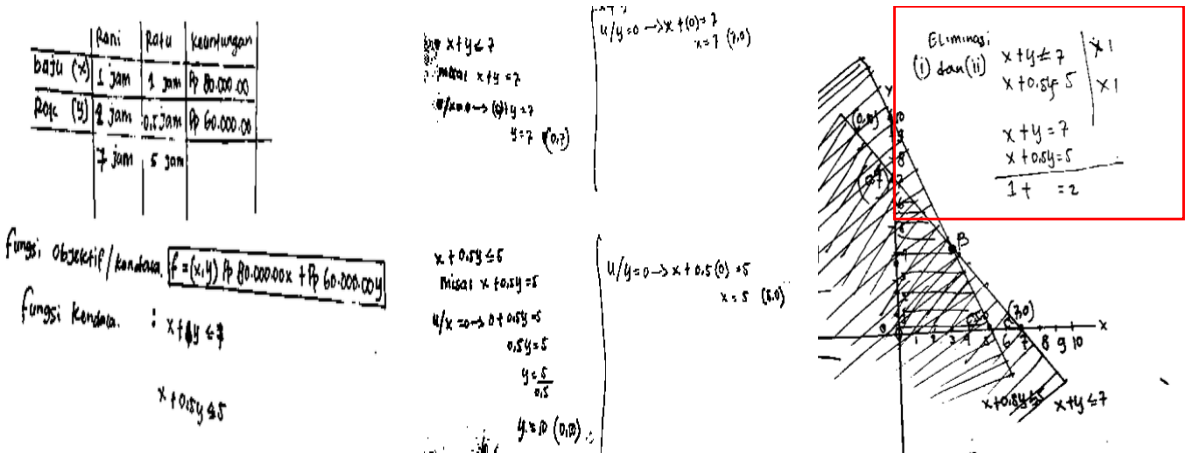

Figure 2. Results of SS Students' Answers

The researcher conducted an interview to obtain more information about the mistakes made by the subject. The following is an excerpt of the results of the researcher's interview with SS.

SST1047P : Okay we continue well, try to pay attention to the elimination method that you wrote. can you explain what you wrote? (pointing to test result 1)
SST1048S : Oh, that one I'm confused about how to calculate.
SST1049P : So, you did not continue to the next step because you were confused in the elimination method?
SST1050S : No, actually I was still confused when I got to the next solution.
SST1051P : How to find the extreme point and determine the maximum profit is also still confused?
SST1052S : Yes, sis

Based on the results of the interview with SS, it was obtained that SS could not complete the calculation using the elimination method as evidenced by the excerpt from the interview SST1048S, SS also did not continue his answer because SS was still confused about the next step as in the excerpts of the interview SST1050S, SST1051P and SST1052S so that SS could not write the final answer and did not write the conclusion of the answer.

Based on the test results and interviews, it is obtained: (1) SS made a mistake in the calculation using the elimination method because SS was still confused and not careful in solving it which in error analysis based on *Newman's Error Analysis is* called a type of error in process skills *(Process Skill Error)*. (2) SS did not write the final answer to the problem given this was because SS did not understand the solution process in the problem and was still confused to proceed to the next step which in error analysis based on *Newman's Error Analysis is* called the type of error in writing the final answer *(Encoding Error)*.

SR Student Error Analysis Based on *Newman's Error Analysis*

Based on SR's answer in Figure 3. in the solution SR is wrong in determining the known part of the problem so that SR makes an equation that is not appropriate as a result of the resulting intersection point is also wrong, in the solution SR also looks still confused in determining the value of the division result and makes the intersection point carelessly, SR also does not continue to the next step so SR does not get the final answer and does not make a conclusion on his answer.

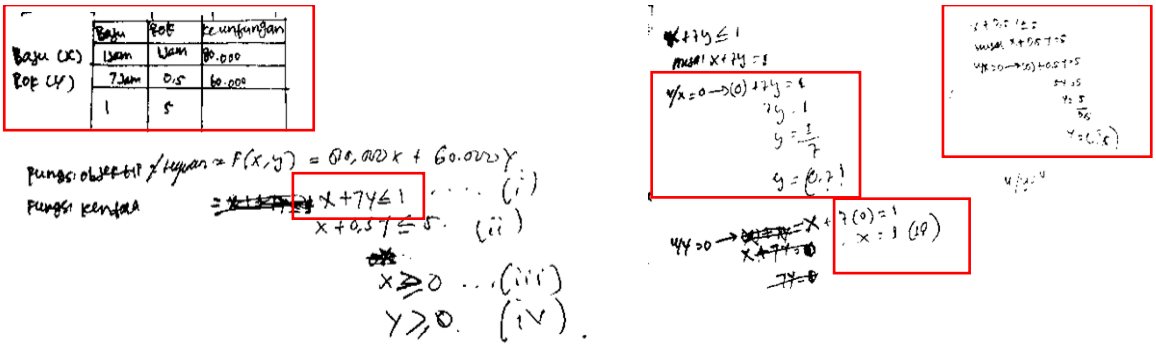

Figure 3. Results of SR Students' Answers

The researcher conducted an interview to obtain further information about the mistakes made by the subject. The following is an excerpt of the results of the researcher's interview with SR.

SRT1011P : From the fragment of the problem, do you understand what is known from the problem?
SRT1012S : (starts to get nervous answering) Emm, don't know sis.
SRT1015P : Explain how you made this math model!
SRT1016S : from here (pointing to the table of test results 1)
SRT1017P :Read out what equations you used to solve the problem!
SRT1018S : x + 7y ≤1 (x plus seven y less than equals 1)
SRT1019P : x + 7y ≤1 is from where?
SRT1020S : (starting to look confused) emm, from this table sis
SRT1027P : Explain how you solved this equation (pointing to the answer of test 1).
SRT1028S : That's if x=0 (x equals zero) y gets 1/7 (one-seventh) kak.
SRT1029P : Then why is the point (0,7)?
SRT1030S : I didn't know what the result of 1/7 (one-seventh) was, so I just wrote the point (0.7)
SRT1035P : So, what's the next solution?
SRT1036S : I don't know how to proceed anymore sis
SRT1037P : okay, if you make a graph, do you know how?
SRT1038S : (getting confused) emm, don't know either kak
SRT1039P :So, what is the conclusion?
SRT1040S : Umm, don't know sis

Based on the results of the interview with SR obtained information that SR made a mistake in writing what is known in the problem where SR looks nervous and confused in explaining the results of his answer. This is because SR still does not understand the meaning of the problem as evidenced in the excerpt of SRT1012S interview. In addition, SR also has not been able to make a mathematical model of the problem given where SR wrote $x + 7y \leq 1$ which should be $x+y \leq 7$ as in the excerpts of SRT1018S and SRT1020S interview results where SR looks confused and cannot explain the answers that have been written. The next mistake made by SR lies in the calculation operation performed when solving the problem where SR writes the value of 1/7 to 7. This is evidenced in the excerpts of SRT1028S and SRT1030S interviews. SR in solving the problem also did not write a conclusion on his answer because SR did not know how to work to the next step so SR could not write a conclusion on his final answer as evidenced in the interview excerpts SRT1036S, SRT1038S and SRT1040S .

Based on the results of tests and interviews, it is obtained: (1) SR is wrong in writing what is known from the problem so that SR cannot determine the equation correctly which in error analysis based on *Newman's Error Analysis is* called a type of error in understanding the problem *(Comprehension Error).* (2) SR cannot make a mathematical model of the given problem because SR does not understand and is not careful in working on the problem, which

in error analysis based on Newman's Error Analysis is called a type of error in transformation *(Transformation Error).* (3) SR is wrong in performing calculation operations when solving the problem which in the error analysis based on Newman's Error Analysis is called a type of error in process skills *(Process Skill Error).* (4) SR did not write the conclusion in the final answer because SR did not understand how to solve the problem correctly, which in error analysis based on *Newman's Error Analysis is* called the type of error in writing the final answer *(Encoding Error).*

Based on the data that has been obtained, further description of the types of student errors in solving problems is presented in Table 3.

Table 3. Description of Student Error Types Based on *Newman's Error Analysis*.

Subject	Category	Indicator	Conclusion
ST	- Errors in writing the final answer	5	ST made a mistake in writing the final answer.
SS	- Errors in Process skills - Errors in writing the final answer	4 5	SS made mistakes in the process skills stage and writing the final answer
SR	- Misunderstanding - Transformation error - Errors in process skills - Errors in writing the final answer	2 3 4 5	SR made mistakes at the stage of understanding, transforming, performing process skills and writing the final answer.

Based on Table 2. it can be seen that **ST** made mistakes in writing the final answer. This is because the subject forgot, was less careful, did not think about it, answered directly to the core of the answer and was in a hurry. **SS** made mistakes in process skills and writing the final answer. This is because the subject forgot and was less careful, confused and still did not understand the problem solving. In line with this. **SR** made mistakes in understanding, converting the problem into mathematical form, performing process skills and writing the final answer. This was due to deliberate answering without using the calculation/formula correctly because he did not know the correct way to solve the problem and lack of accuracy.

Errors in understanding the problem, namely incorrect or not knowing the information known from the problem, problem transformation errors, namely not being able to convert the problem into mathematical form correctly, process skill errors, namely students do not write or cannot solve the equations made correctly and are not skilled in determining the steps to be used to solve the problem, Errors in writing the final answer, namely not writing or writing the wrong conclusion in the final answer.

The error made by ST in solving the story problem of linear program material based on *Newman's Error Analysis* (NEA) is that ST does not write the conclusion in the final answer. the cause of the error in writing the answer is because in the previous stage students forgot what was initialized so that students wrote answers that were not correct and did not match what was asked in the problem. (Simangunsong, et al 2021).

The error made by SS in solving story problems of linear program material based on *Newman's Error Analysis* (NEA) is that SS does not continue the problem solving procedure correctly, such as research conducted by Amelia (2018) who wrote that the factors for errors in solving story problems based on Newman include students not knowing the procedures or steps to be used to solve the problem. In addition, SS also did not write a conclusion on the results of his answer. In line with that, Rismawati & Asnayani (2019) also wrote that the causes of answer writing errors are students' difficulties when writing the final answer or unit in accordance with the question request, students' low ability to determine the solution to mathematical problems, students' weak arithmetic skills, students are not accustomed to checking the results obtained, and students are not accustomed to writing conclusions.

The error made by SR in solving the story problem of linear program material based on *Newman's Error Analysis* (NEA) is that SR makes mistakes in writing what is known and asked from the problem, this is in line with research conducted by Gustiani & Puspitasari (2021) that errors in determining known information can be caused by students' limited reading comprehension skills. SR in its solution is also wrong in changing the form of the problem into a mathematical model, Sunardiningsih, et al (2019) wrote that transformation errors, namely students do not know what formulas and stages of arithmetic operations will be used to solve the problem. This error is caused by students not being able to determine the known components of the problem to be used as material to obtain the answer to the problem (Fachis, et al. 2020). SR is also wrong in solving the equation, it can be seen that SR is also wrong in performing the division calculation operation so that the point obtained does not become inappropriate, Amelia (2018) who wrote that the factors for errors in solving story problems based on Newman include students not knowing the procedures or steps that will be used to solve the problem. It can be seen from the results of SR's answer that he also did not make the final answer to the problem so that SR could not write the conclusion of solving the problem, the cause of this error is that students deviate from the method used previously and students' ignorance in concluding the final answer (Lanya, et al. 2022). Rismawati & Asnayani (2019) also wrote that the causes of answer writing errors are students' difficulties when writing the final answer or unit in accordance with the question request, students' low ability to determine solutions to mathematical problems, students' weak arithmetic skills, students are not accustomed to checking the results obtained, and students are not accustomed to writing conclusions. The cause of this error is that students deviate from the method used previously and students' ignorance in concluding the final answer.

CONCLUSION

Based on the results of research and discussion, it can be concluded that the errors of class XI students of SMA Negeri 1 Sirenja in solving story problems of linear program material based on *Newman's Error Analysis* (NEA) are (1) *comprehension error*, namely students incorrectly write the known information from the story problem of linear program material. (2) *transformation error*, namely students are wrong in making the mathematical form of the problem where students write $x + 7y \leq 1$ which should be $x + y \leq 7$. (3) *process skill error*, namely students are wrong in performing calculation operations when solving problems where students write the value of $1/7$ to 7. (4) *encoding error*, namely students do not write conclusions in their final answer.

RECOMMENDATION

The suggestions that researchers can give to reduce or minimize student errors on linear program material are (1) Knowledge of the results of the analysis of student errors in solving story problems based on *Newman's Error Analysis* (NEA) can be used to design learning models and strategies that aim to improve and optimize students in solving linear program material story problems; (2) Teachers should pay more attention to linear program material because the material is considered one of the difficult materials for students to solve; and (3) Students should do a lot of practice working on story problems of linear program material in order to further improve their understanding of the material.

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