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ANALYSIS OF VOCATIONAL SCHOOL STUDENTS' ERROR IN SOLVING LINEAR PROGRAM PROBLEMS

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ABSTRACT

The reality on the ground shows that students still make mistakes in solving problems in the form of Linear Program stories. This study aims to describe students' mistakes in solving word problems in linear programming material. The method used in this research is descriptive qualitative research. The subjects in this study were class X students of Karya Bahana Vocational School, Bekasi City. The instrument in this study was in the form of 5 questions in the form of descriptions. In addition to the instrument in the form of tests, interviews were used to dig deeper into students' answers to the questions presented. The results showed that the most errors made by students were in the aspect of errors in writing the final answers, and the fewest errors were in the aspects of transformation errors. The cause of reading errors is that students are unable to interpret sentences correctly and cannot find key words and important information. The cause of the error in understanding the problem was that students did not include the known data and the data asked. The causes of errors in the transformation are students not being able to model everyday sentences into mathematical symbols and errors in using mathematical operations. The cause of the process skill error was that the student was unable to write down the objective function and the student was unable to continue with the answer, while the cause of the error in writing the final solution was the inability of the student to draw conclusions correctly.

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INTRODUCTION

Word problem is a task that serves to determine problem-solving abilities. Word problems function so that students are able to associate mathematical concepts with real life. The presentation of real-world situations is usually presented in word problems in the form of text without containing mathematical symbols (Boonen, De Koning, Jolles, & Van Der Schoot, 2016). The main activity in solving math word problems, students must be able to identify data that is relevant to real life in the form of text and transform it into mathematical symbols. The ability to relate the mathematical material that has been studied with the real life of students (Angateeah, 2017) .

The function of word problems has a very important role in learning mathematics, but word problems are tasks that tend to be difficult for students to complete. Students' difficulties in solving word problems can be identified through student errors in providing relevant information to the questions presented by the questions (Hadi, Retnawati, Munadi, Apino, & Wulandari, 2018). Besides errors in understanding information, students also experience errors in designing mathematical models and solving algorithms shown (Jupri & Drijvers, 2016). Previous student errors can be caused by students' lack of skill in reading comprehension, so that students have difficulty interpreting words in story problems (Boonen et al, 2016). In addition to reading comprehension skills, student errors can also be caused by students not being skilled at solving problems, problem solving abilities are directly related to students' representation abilities (Sajadi, Amiripour, & Rostamy-Malkhalifeh, 2013).

Algebra is one of the materials considered at the high school level. According to Yunani, Awi, & Asdar (2015) algebra tends to be perceived by students as a subject that is difficult and abstract in nature, because in order to think algebraically students must be able to understand patterns, and use mathematical models to represent and understand relationships quantitatively. The subject matter of algebra that students learn at school is used to solve problems in real life (Haryarti et al, 2016). Linear programming is one of the main topics in algebra material. Students are required to be able to model from everyday language into mathematical models in solving story problems. According to Karnasih (2015), the function of mathematical models is to assist students in understanding the process of changing real situations into mathematical symbols (mathematizing).

The reality on the ground shows that students still find it difficult to work on linear programming word problems. This is evidenced by (Andriani & Ratu, 2018) in his research with Linear Programming material, it was seen that many students made mistakes. Errors experienced by students included errors in modeling in the form of mathematical symbols, errors in determining corner points, and not returning to the questions posed. The difficulties experienced by students in answering story questions in linear programming material were mentioned by Utari, Wardana, & Damayan (2019), that is, students often find it difficult to solve linear programming questions due to a lack of understanding of the questions and difficulty using arithmetic operations. Gunawan (2017), some of the difficulties of students in solving linear programming problems include difficulty understanding questions, changing linear program problems into mathematical models, difficulties in calculating and difficulty making conclusions. Furthermore Noviani (2019) states that if in solving math problems and students do not or use abstract mathematical objects, it is certain that these students have experienced errors or there are deficiencies in the problem solving process. Which means if students make mistakes in solving problems then this is an indicator that students still have difficulties in solving problems.

From the problems that have been described, it is necessary to seek ways to reduce student errors when working on word problems in linear programming. The first step in dealing with

students solving math problems is to map students' mistakes in solving math problems (Hadi et al., 2018; Pradini, 2019; Rafi & Retnawati, 2018). By knowing the mistakes students make when working on word problems, the teacher can find alternatives to solve these problems and can design effective learning steps, to reduce similar mistakes made by students. According to Nurhasanah et al (2016), further analysis is used to see the mistakes made by students, to see more clearly and in detail the students' mistakes when solving word problems. Besides that, it can encourage students to learn better from mistakes and failure to complete correctly (Kapur, 2014).

To analyze these errors Newman analysis can be used. The Newman procedure is used to understand and analyze when students solve a problem in a problem (Rahmawati & Permata, 2018). Newman's Error Analysis consists of errors in reading (reading), understanding the problem (Comprehension), problem transformation (transformation), completion process (process skill) and writing conclusions (encoding).

There has been a lot of error analysis on the topic of mathematics, such as describing student errors in systems of two-variable linear equations (Sangadah, 2016), quadratic inequalities (Jamal, 2018), prism volume (Nurhassafa'at et al, 2016), and and side shapes flat (Damawan et al, 2018). However, error analysis in solving linear programming problems has not been widely carried out, especially using the Newman procedur.

From the description that has been stated previously, it can be concluded that the identification of student errors in solving linear programming problems is very important to examine the description of student errors when solving linear programming problems. This description can be used as material for reflection for teachers in improving learning activities on material that is difficult for students to learn, especially in linear programming material. Thus, this study aims to describe the mistakes of Gema Karya Bahana Vocational High School students in Bekasi City in solving word problems in linear programming material based on Newman's error analysis procedure. The selection of linear programming material is because this material is considered difficult by students and there are many linear programming concepts that can be used in everyday life.

METHOD

Qualitative descriptive method is the method used in this study. The purpose of this study was to examine and describe students' mistakes when solving problems in linear programming material. The analysis used in this study is Newman's analysis. The subjects in this study were 15 class X students of Gema Karya Bahana Vocational School, Bekasi City. The instrument used in this study was a written test in the form of a description of 4 questions. The results collected in this study were in the form of students' written answers. The students' written answers were used to analyze and determine the types of mistakes students made in solving word problems in linear programming material. Furthermore, a reduction is made to the test results so that useful conclusions can be obtained in analyzing and describing the errors made by students in solving linear programming problems based on the Newman error analysis procedure. To see the percentage of student errors in each item, the following formula is used:

$$P = \frac{n}{N} \; x \; 100\%$$

Information:

P	:	Percentage of error types
n	:	The number of errors for each type of error
N	:	The number of possible errors

RESULTS AND DISCUSSION

Results

Based on Newman's procedure, students' errors in solving problems can be categorized into five types, as follows: (1) reading errors (A), (2) understanding problems (B), (3) changing problems (transformation) (C) , (4) completion process (process skills) (D) and (5) writing conclusions (encoding) E. Code T if the student answered correctly and F if the student answered the question incorrectly is shown in Table 1.

Table 1. Error Type

Student	Error Type			
	Question Number 1	Question Number 2	Question Number 3	Question Number 4
1	A	B	D	A,C
2	B	A	F	A,C
3	T	B	D	A,C,E
4	A	A,	F	C
5	E	A,B	BD	C,E
6	D	A,D,E	A,D	B
7	A	B	D	C,E
8	E	F	D,E	B,C
9	E	B	B,D,E	B,C,E
10	B	C,E	C,E	A,C,D
11	B	A	A,B,D,E	E
12	D,E	E	C	E
13	D,E	D	E	E
14	A,B,E	D,E	B,E	E
15	T	A,E	B	E

From Table 1 it is described about the mistakes made by students in working on linear programming questions. The following in Table 2 shows a recapitulation of the percentage of student errors.

Table 2. Recapitulation of Percentage of Student Errors

Error Type	Number of Students who Make Mistakes				Total	Percentage
	1	2	3	4		
Reading	2	5	2	3	12	20,00%
Comprehension	4	5	5	3	18	30,00%
Transformation	1	0	6	2	9	15,00%
Process skill	3	3	8	1	15	25,00%
writing conclusions	6	5	6	9	30	43,33%

Table 2 shows that the most student errors in solving questions were coding errors of 43.33%, while the fewest errors were transformation errors (15.00%), followed by types of errors. others, namely 30% comprehension error, 25% processing skill error and 20.00% reading error. Each error made by students is discussed in more depth in the following section:

Reading Error

The number of students who experienced errors in reading were 12 students with an error percentage of 20.00%. This shows that only a small proportion of students make reading errors. The causes of this reading error are student errors in interpreting sentences correctly, errors when identifying key words in questions and errors in reading information and mathematical notation in solving problems.
Figure 1 shows the error of Student 1 (S-1) in reading in question number 1

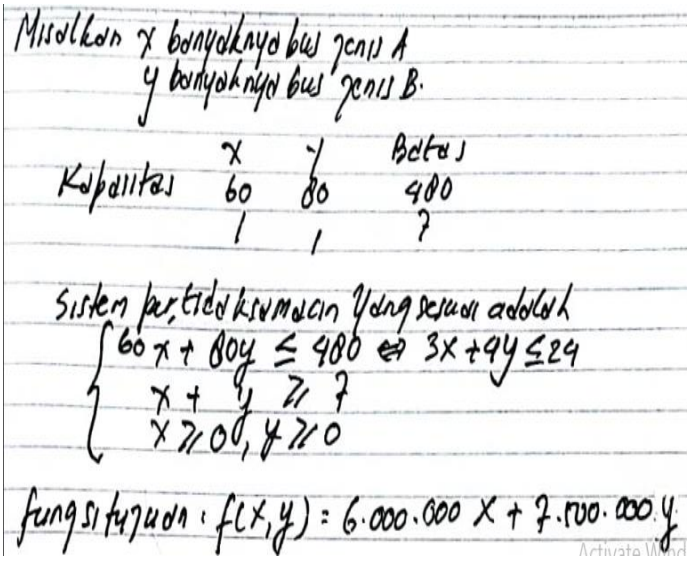
Soal 1 Nomor 1	Jawaban Soal No. 1
Sebuah sekolah akan mengadakan "karyawisata" akan meminjam 2 jenis kendaraan dalam waktu 3 hari, kendaraan tipe A memuat 60 orang dengan biaya Rp. 6.000.000 dan kendaraan B memuat 80 orang dengan biaya Rp. 7.500.000. Kegiatan ini diikuti 480 orang. Jika diperlukan maksimal 7 buah kendaraan, maka tentukan banyaknya kendaraan yang perlu disewa untuk meminimalisir pengeluaran.?	

Figure 1. Error reading questions

From Figure 1 it can be seen that students made reading errors, because students did not carefully read the information presented in the problem. In this case, it is known that the "field trip" was attended by 240 people. However, because S-1 was not careful when reading the questions, students made mistakes in making mathematical notation with the symbol ≤ which should be ≥, whereas in the problem it is known that "cars" are needed at most 7 units". However, because S-1 misinterpreted the language into mathematical notation i.e ≥ should be ≤

Below is the result of an interview with S-1 about misreading the questions.

P : Why did you write in mathematical notation, the number of students who took part in the field trip was 240 people with $3x+4y \leq 24$
S1 : Because I think that the number of students who take part is less than 240
P : Why do you write in mathematical notation, if the number of buses required is at most 7 buses with $x+y \geq 7$
S1 : Because in the problem it is known the most, I write ≥

Based on the results of written tests and interviews, it can be concluded that students who experience reading difficulties occur when students are unable to interpret sentences that are read correctly. In this study, the mistakes made by students were reading errors in terms of understanding sentences correctly, errors in finding the correct keywords or data in the problems presented and errors in modeling everyday language into mathematical symbols (Rindyana, 2013).

Understanding the Problem (Comprehension) Error

The number of students who experienced errors in understanding the problem (understanding) was 18 students with an error percentage of 30.00%. This shows that the error in understanding the problems experienced by students is still quite high. The cause of the error in understanding the problem is difficulty in understanding the problem, including errors by not writing down the known data and the data being asked. An example of an misunderstanding is an error made by subject 5 (S-5). An example of this error can be seen in Figure 2.

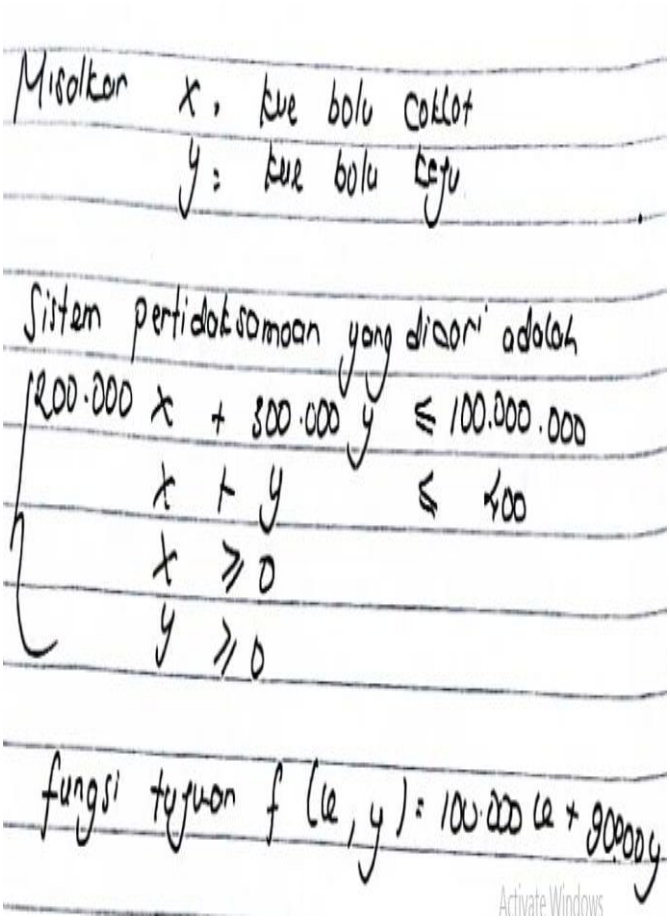
Soal nomor 2	Jawaban nomor 2
Bu Dani menjual dua jenis kue yaitu bolu coklat dan kue bolu keju. Kue bolu colkat dibeli dengan harga Rp 200.000 dan dijual dengan untung 50%. Kue bolun keju dibeli dengan harga Rp 300.000 per bolu dan dijual dengan untung 40%. Jika Ibu Dani mempunyai modal Rp 100.000.000,00 dan menjual maksimal 400 bolu tiap hari, berapa keuntungan terbesar yang Ibu Dani peroleh?	

Figure 2. Error Understanding the Problem (Comprehension**)**

In Figure 2 it can be seen that S-5 students experience difficulties because they do not write down the data that is known and the data that is asked. In general, students make mistakes by writing data that is known but wrong. However S-5 does not state the known data and the data asked at all, S-5 only exemplifies the example of chocolate cake = x and cheese cake = y and directly models the problem into mathematical symbols (Figure 2).

Below are the results of an interview with S-5 about 2 Error Understanding the Problem

P **:** why don't you write down the known data and the data asked from question number 2

S-5 **:** I don't understand the important information and keywords used to solve the

problem

Problem transformation Error

The number of students who made mistakes in the transformation was 9 students with an error percentage of 15.00%. The data shows that describing the transformation errors made by students is very low and the lowest among other indicators. The transformation errors in this study were in the form of errors in changing everyday language into correct mathematical models, not understanding the algorithms in solving the problems presented and not being careful in working on problems and performing calculations using wrong operations. An example of this error can be seen in Figure 3.

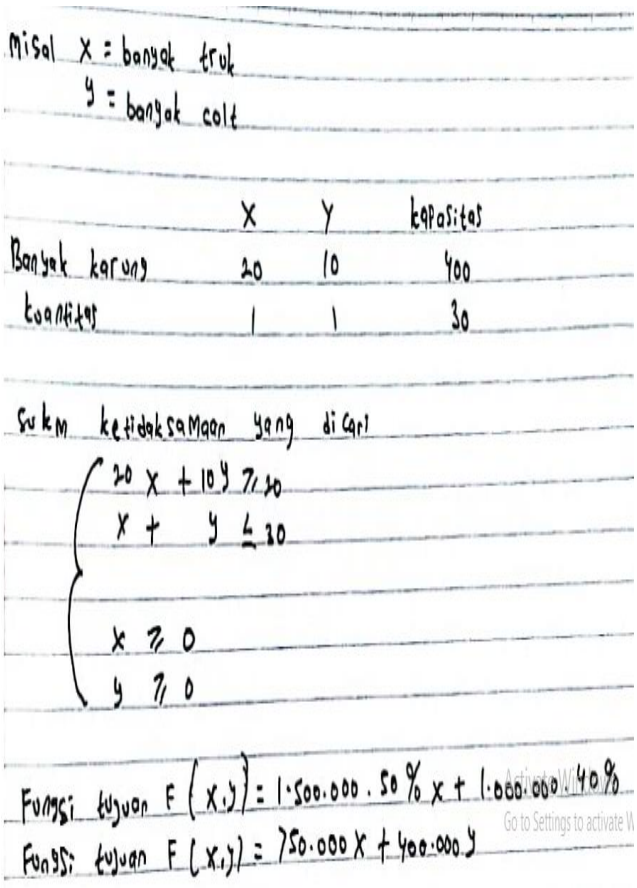
Soal nomor 3	Jawaban soal nomor 3
Seorang pengusaha akan menyewa paling sedikitnya 30 unit kendaraan untuk jenis kendaraan truk dan colt, dengan jumlah karung yang dapat diangkut 400 karung. Truk tersebut dapat mengangkut tidak lebih dari 20 karung dan 10 karung untuk colt. Biaya sewa truk Rp. 1.500.000,00 dan Rp. 1.000.000,00 ekor. Kalau untuk sewa Truck ada diskon 50% dan sewa Colt ada diskon 40%. Tentukan biaya minimum yang harus dikeluarkan.	

Figure 3. Error Problem Transformation

Figure 3 shows that S-10 made a transformation error, namely not being able to change everyday language into a mathematical model and an error in carrying out the operation in working on the problem. Figure S-10 incorrectly determines the objective function, which must be 50% x 1,500,000+ 40% x 1,000,000 y or f(x,y) = 750,000 x + 500,000y can be seen in Figure 3.

Below are the results of an interview with S-10 about 3 Error Problem Transformation.

P **:** Why would you write the minimum objective function as follows:
f(x,y) = 750.000 x + 500.000y

S-5 **:** I don't understand the discount issue and don't pay attention to the conditions for creating a minimum objective function.

Completion process (process skill) Error

The number of students who experienced process skill errors was 15 students with a process skill error percentage of 25.50%, this indicated that process skill errors were classified as moderate. In the skill error process there are still many students who make mistakes, namely in the form of misunderstanding concepts, calculation errors and errors in performing arithmetic operations and carrying out the solving algorithm. Actually there are not a few students who are able to determine arithmetic operations but do not know the steps to be used to solve the problem correctly, so that many students do not continue the completion procedure until it is finished. An example of a process skill error made by subject 13 (S-13) is shown in Figure 4

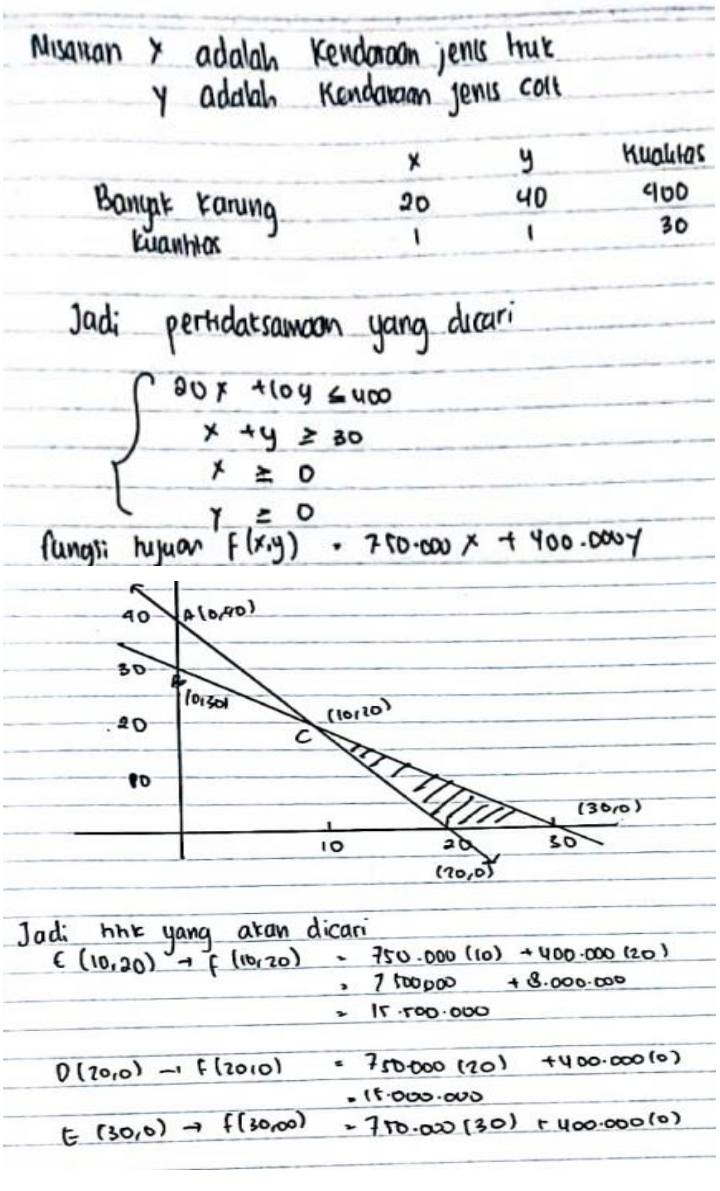
Soal nomor 3 Seorang pengusaha akan menyewa sedikitnya 30 unit kendaraan truk dan colt, karung yang dapat dibawa 400 karung. Truk paling banyak membawa 20 karung dan 10 karung untuk colt. Biaya penyewaan truk Rp. 1.500.000 dan Rp. 1.000.000. Kalau untuk sewa Truck ada diskon 50% dan sewa Colt ada diskon 40%. Tentukan biaya minimum yang harus dikeluarkan..	Jawaban Soal Nomor 3 

Figure 4. Error completion process (process skill)

In Figure 4 students made an error in the Error completion process (process skill) in the form of being wrong in determining the result area, namely the area containing points C(10,20), D(20, 0) E (30,0) which should be the area containing points A (0,40), B(0,30) and C(10,20) so that an error occurs in determining the minimum cost asked in the problem.

Based on the interview results obtained as follows:

P : Why do you answer that the problem solving area contains points C(10,20), D(20,0) dan E (30,0)

S-13 : Because I consider this area to meet the constraints, namely $20 x + 10 y \leq 400$ and $x + y \geq 30$

Writing conclusions (encoding) error.

The number of students who made coding errors was 30 people with a percentage of 43.33. This stated that the error in writing the final solution was the most common error made by students compared to other errors. Errors that occur in writing conclusions (encoding) are shown in Figure 5.

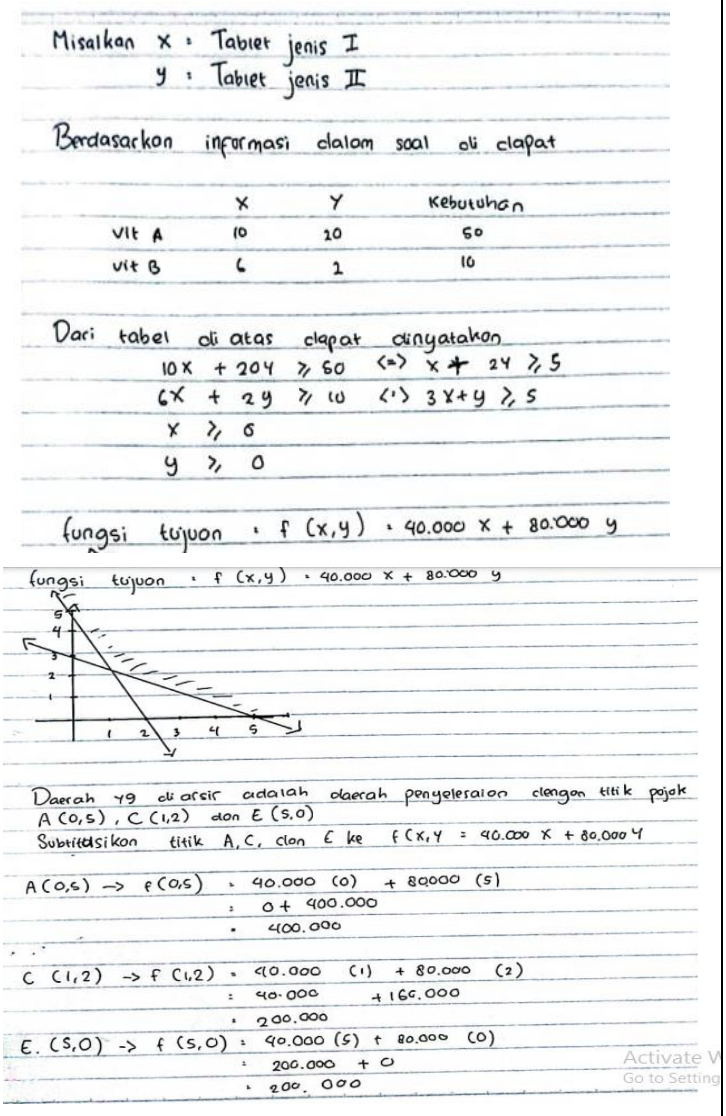
Soal Nomor 4	Jawaban soal nomor 4
Seorang pasien yang sakit diwajibkan meminum dua tablet setiap hari. Tablet I terdiri 10 bagian vitamin C dan 6 bagian vitamin D. Tablet II terdiri 20 bagian vitamin C dan 2 bagian vitamin D Setiap hari, pasien membutuhkan 50 bagian vitamin C dan 10 bagian vitamin D Jika harga tablet I adalah Rp 40.000 per tablet dan Rp. 80.000 per tablet II, kemudian tentukan berapa tablet I dan tablet II agar pengeluaran minimal untuk pembelian tablet?.	

Figure 5. Error writing conclusions (encoding).

In Figure 5, it can be seen that S-14 made an error in writing the final answer (encoding). It turned out that S-14 was able to find the final result correctly, namely the minimum cost used to buy a tablet. Rp. 20,000.00, but students made mistakes, namely they could not show the final answer correctly and could not write the final answer according to the data asked. The final answer is that the required drinking fee is Rp. 200,000 with 1 tablet of type 1 and 2 tablets of type II.

Based on the interview results obtained as follows:

P : Why don't you give a conclusion after solving the problem

S-14 : I feel confused about how to draw conclusions because there are two answers that are the same

Discussions

From the results of the research that has been presented, to be further described in detail regarding student errors based on the Newman analysis procedure as follows

Reading Error

From the results described, it was found that the causes of reading errors made by students were errors in understanding sentences correctly, errors in determining important words in questions, and errors in reading or interpreting complete mathematical information and symbols. This opinion is in accordance with the opinion of Rohmah & Sutiarso (2018), which stated that reading errors occur when students do not identify information and mathematical symbols in the problem.

Understanding the Problem (Comprehension) Error

From the results that have been put forward, it can be concluded that the cause of misunderstanding about the problem is that students do not write down the data they know and do not write down the data asked in the problem. According to research conducted by Chusnul, Mardiyana, & Retno (2017); Amalia, Aufin, & Khusniah (2018); Paladang, Indriani, & Dirgantoro (2018) The cause of students making mistakes in understanding the questions is in the form of not stating a written statement of the problem. This is due to a lack of understanding of the data contained in the questions, besides that students do not understand the problems presented in the questions, so that the information presented is incomplete. Another opinion was also expressed by Febriani & Mukhni (2018); Darmawan, Kharismawati, Hendriana, & Purwasih (2018); Rahmawati & Permata (2018: 183), namely errors that occur when students do not determine the data that is known and the data that is asked in the problem.

Problem transformation Error

From the results that have been stated, it can be concluded that the cause of the error in the transformation is: not being able to change everyday language into a mathematical model. and students are less able to determine the right formulas and algorithms in the process of solving problems on questions. This is in line with the opinion of Brown & Skow (2016) who said that one of the mistakes students made in solving word problems was changing relevant information into mathematical equations.

Completion process (process skill) Error

From the results that have been stated, it can be interpreted that the cause of process skill errors is not understanding the algorithm used when solving the problem correctly, errors in doing such as writing the objective function to be completed incorrectly, errors in describing the settlement area according to linear program story problems. This agrees with Rahmawati

& Permata (2018), also stating that process skills errors occur because students do not know the procedure that must be used to solve the problem. stating that the process of skill errors is caused by students not understanding the steps that must be taken in solving the problems presented.

Writing conclusions (encoding) error.

From the results that have been stated, it can be concluded that the students' mistakes in writing the final answer were not being able to find the final answer correctly, not being able to write the final answer correctly and not being able to write the final answer. answer correctly. final answer correctly. conclusions according to the results obtained. According to Santoso, Farid & Ulum (2017), errors in writing final answers (encoding errors) occur because they are unable to write down final answers even though students have successfully processed the data. This error is caused by errors and students do not understand the problems presented.

CONCLUSION

The results showed that the most errors made by students were in the aspect of writing the final answer, while the fewest errors were in the aspect of transformation errors. The cause of reading errors is that students are unable to interpret sentences correctly and cannot find key words and important information. The cause of student errors in the aspect of understanding the problem is that students do not state the known data and the data asked in the problems presented. The causes of transformation errors are students not being able to model everyday sentences into mathematical symbols and errors in using mathematical operations. The cause of process skill errors is that students cannot write down the objective function which is known from the questions and students cannot continue with the answers, while the cause of errors in writing the final solution is that students do not draw conclusions correctly. By recognizing mistakes when students work on problems in the form of linear program stories using Newman's analysis, it is hoped that teachers can determine the right learning design to prevent similar mistakes from occurring. Based on the findings of this study, it is suggested to teachers to strengthen students' conceptual understanding of the material being studied. Teachers also need to make improvements in the learning process, also utilize various media and technology in the teaching and learning process as an effort to make the learning process even better.

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