Analysis of Grade X Students' Errors in Solving Linear Programming Problems Using K-Means Clustering

Rifana Arthaningrum[1*], Otong Suhyanto[2], Khairunnisa[3]
[1, 2, 3] UIN Syarif Hidayatullah Jakarta, Banten, Indonesia
*Correspondence: rifanaarthaningrum31@gmail.com

ABSTRACT

This research aims to analyze the errors of grade X in solving linear programming problems, knowing the clusters formed based on the errors made by students, knowing the errors that dominate in each cluster, and knowing the most significant types of errors in distinguishing each cluster that is formed. This research was carried out at State High School 9 Jakarta in 2023/2024 academic year. This research uses a quantitative approach involving 216 students in grade X. This research uses Newman's Error Analysis procedure to analyze the types of errors, namely Reading Error, Comprehension Error, Transformation Error, Process Skill Error, and Encoding Error. Data collection was carried out using a test in the form of description. The results of this research revealed that no student has been able to solve the linear programming problems without making errors. Students are grouped into 2 clusters based on the error score possessed on each type of error using K-Means Clustering method. The cluster results showed that 177 students were in cluster 1 with a high error rate category, and 39 students were in cluster 2 with a low error rate category. The types of errors that contribute the most in distinguished cluster 1 from cluster 2 consecutively are encoding error, process skill error, comprehension error, transformation error, and reading error. Based on the results of the research, it can be concluded that most of students have a high error rate. This shows that there are indications that most of students still do not understand the linear programming material well.

Keywords: Errors, Newman's Error Analysis, K-Means Clustering, Linear Programming

ABSTRAK

Penelitian ini bertujuan untuk menganalisis kesalahan-kesalahan siswa kelas X dalam menyelesaikan masalah program linear dengan mengetahui *cluster* yang terbentuk berdasarkan kesalahan yang dilakukan siswa, mengetahui kesalahan yang mendominasi pada masing-masing *cluster*, serta mengetahui jenis kesalahan yang paling signifikan dalam membedakan setiap *cluster* yang terbentuk. Penelitian ini dilaksanakan di SMAN 9 Jakarta tahun pelajaran 2023/2024. Penelitian ini menggunakan pendekatan kuantitatif yang melibatkan 216 siswa kelas X. Penelitian ini menggunakan prosedur *Newman's Error Analysis* untuk menganalisis jenis-jenis kesalahan siswa, yaitu *Reading Error, Comprehension Error, Transformation Error, Process Skill Error,* dan *Encoding Error*. Pengambilan data dilakukan dengan menggunakan instrumen tes berbentuk uraian. Hasil penelitian mengungkapkan bahwa belum ada siswa yang mampu menyelesaikan masalah program linear tanpa melakukan kesalahan. Siswa dikelompokkan menjadi 2 *cluster* berdasarkan skor kesalahan yang dimiliki pada setiap jenis kesalahan dengan metode *k-means clustering*. Hasil *cluster* menunjukkan bahwa sebanyak 177 siswa berada di *cluster* 1 dengan kategori tingkat kesalahan tinggi, sedangkan 39 siswa berada di *cluster* 2 dengan kategori tingkat kesalahan rendah. Jenis kesalahan yang paling berkontribusi dalam membedakan cluster 1 dengan cluster 2 secara berturut-turut adalah *encoding error*, *process skill error, comprehension error, transformation error*, dan *reading error*. Berdasarkan hasil penelitian, dapat disimpulkan bahwa sebagian besar siswa memiliki tingkat kesalahan yang tinggi. Hal tersebut menunjukkan adanya indikasi bahwa sebagian besar siswa masih belum memahami materi program linear dengan baik.

Kata Kunci: Kesalahan, *Newman's Error Analysis, K-Means Clustering,* Program Linear

Introduction

Linear programming is important material to learn and master because its application is broad in everyday life. This material is a mathematical material that requires contextual problem solving abilities. Linear programming is a concept commonly used to solve optimal value problems (Rindengan & Langi, 2018). The optimal value is obtained from a set of linear problem solutions. The area or set of solutions is obtained from a system of linear inequalities (Amanda Hidayah et al., 2022). Therefore, linear programming material, especially systems of linear inequalities in two variables, is important to emphasize to students (Asy'ari et al., 2020).

In the curriculum in Indonesia, especially in mathematics books, the substances of the two-variable linear inequality system studied by high school students include: (1) creating mathematical models; (2) solving systems of linear inequalities; (3) explain the meaning of the solution obtained in solving the problem (Susanto et al., 2021). Researchers conducted observations at one of the schools in Jakarta and interviewed the grade X mathematics teacher which showed that quite a few students were not able to solve linear programming problems well. The errors that many students make in solving linear programming problems are when students transform the problem into a mathematical model. Apart from that, there are still many students who cannot determine the correct solution area so they cannot determine the points that will be tested to find out the minimum and maximum values. Based on this information, it can be concluded that students still make a lot of errors when solving linear programming problems.

Students' ability to solve linear programming problems was also demonstrated in a literature study conducted by (Sadiah et al., 2023) for the period 2016 to 2022. The results of this literature study show that students tend to still not produce good results on this material within that time period. the last 7 years (Sadiah et al., 2023). Another research conducted by (Hasana et al., 2022) which analyzes the critical thinking abilities of class XI IPS 4 SMA

Pertiwi 1 Padang on the topic of linear programming. The results of his research showed that 75% of students could not solve linear programming problems and 25% of students could solve them but not all of them were correct (Hasana et al., 2022). Based on the results of previous research and the results of interviews with teachers, the researchers wanted to analyze the errors made by students when solving linear programming problems. The aim of this research is to find out the results of the clusters that are formed based on the errors made by students, to find out the errors that dominate in each cluster, and to find out the types of errors that are most significant in distinguishing each cluster that is formed.

Researchers analyzed student errors based on Newman's Error Analysis theory. Newman's Error Analysis (NEA) is a tool for analyzing students' problem solving techniques so that the results of the analysis can be used as evaluation and reference material in efforts to improve the quality of learning (Ningsi et al., 2022). In detail, Newman identified five types of errors that students make when solving mathematical problems and these were adapted by researchers, namely Reading error is an error that students make when reading information and if students cannot read and explain the information in the problem correctly. Comprehension error is an error made by students when students do not explain how to solve the problem being asked. An example of a comprehension error in linear programming material is that students do not write down the objective function. Transformation error is an error made by students when students cannot transform contextual problems into mathematical models and graphics. An example of a transformation error in linear programming material is that students cannot graph the solution correctly. Process skill error is an error made by students when they are incorrect or incorrect in carrying out the calculation process. An example of a processing error is if a student incorrectly tests corner points. Encoding error is an error made by students when students cannot interpret the answers they have received correctly. Students cannot return answers to their original form.

Method

This research uses a quantitative descriptive approach. Data collection was carried out by giving tests to 216 students of grade X at SMAN 9 Jakarta. The instrument used is a test in the form of a description. Researchers used the k-means clustering method to group students based on the type of error. Before grouping using k-means, there are several stages that must be carried out, such as multicollinearity testing, PCA, and creating a dendogram. After the students were grouped, the researcher carried out discriminant analysis to determine the characteristics of each cluster formed, the types of errors that dominate in each cluster, and the types of errors that significantly differentiate the clusters. The following is a picture of the flow of data analysis carried out in this research:

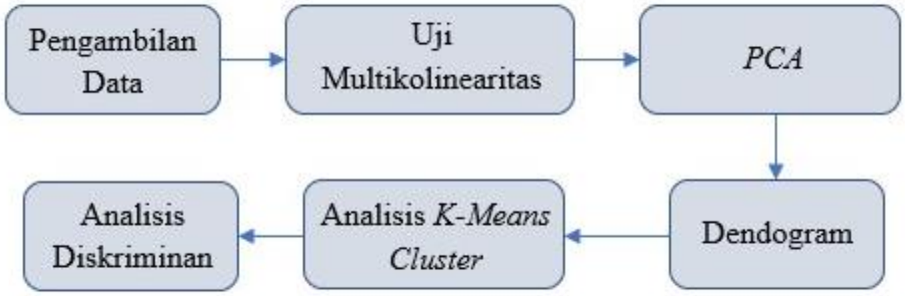

Figure 1. Data Analysis Flow

The multicollinearity test was carried out to test the existence of correlation between variables. The ideal data for cluster analysis is data that is free from multicollinearity. The occurrence of multicollinearity in the data will affect the cluster results (Musfiani, 2019). Researchers use the VIF (Variance Inflation Factor) value to measure the correlation value. If the VIF value is > 10, then multicollinearity occurs between variables. If the VIF value is ≤ 10, then there is no multicollinearity between variables (Ghozali, 2021).

Table 1. Multicollinearity Test Results

Type of Errors	**Collinearity Statistics**	
	Tolerance	**VIF**
Reading	0.890	1.124
Comprehension	0.578	1.730
Transformation	0.554	1.804
Process	0.322	3.110
Encoding	0.355	2.819

The results of the multicollinearity test can be seen in the table above. The test results in table 1 show that the VIF (Variance Inflation Factor) value for all variables is less than 10. So it can be concluded that there is no multicollinearity in all variables, so the data analysis process can be continued and there is no need to reduce variables using Principal Component Analysis (PCA).

At the k-means clustering stage, the number of clusters to be formed is determined by the researcher. Therefore, this research uses a dendogram to determine the optimal number of clusters. The optimal number of clusters can be known based on the maximum or largest distance.

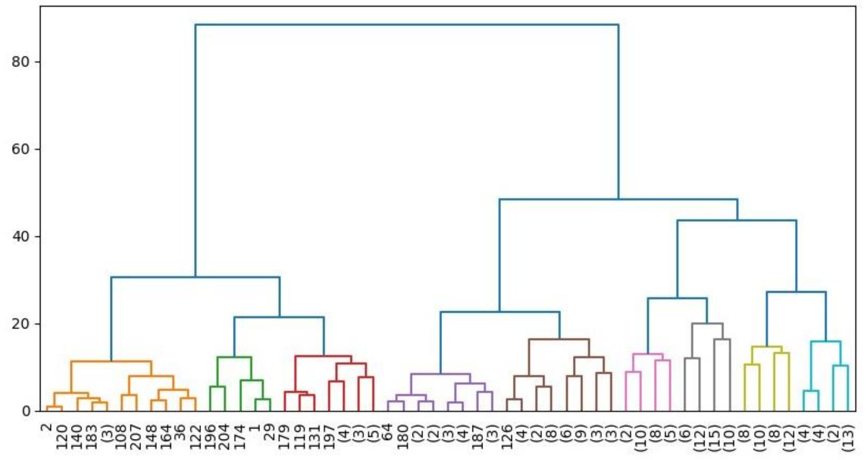

Figure 2. Dendogram Results

Based on the dendogram in Figure 1, a total of 216 students were grouped into several clusters. However, the optimal number of clusters can be seen from the largest line distance. In the dendogram image, the largest line distance is on the top line. The top line divides students into two large groups. So it can be concluded that the optimal number of clusters is two.

After getting the optimal number of clusters, the researcher then analyzed or carried out a calculation process on the data using the k-means clustering algorithm to produce groups of students based on written test results. Clustering is a method for grouping objects or documents where the objects are grouped or classified based on a characteristic or content to facilitate the required search (Grossman & Frieder, 2004). In this research, students will be grouped based on the score of errors made when solving linear programming problems. Clearer steps or algorithms for grouping data using the k-means method are as follows (Muliono & Sembiring, 2019):

a. Determine the number of clusters (k clusters) you want to create.
b. Determine the initial cluster center point or initial centroid randomly.
c. Calculate the distance of each data to the initial centroid using the Euclidean distance formula:

$$d_{ij} = \sqrt{\sum_{k=1}^{n} \left(x_{ik} - x_{jk}\right)^2}$$

with information:

d_{ij} : the distance between the ith data and the jth data

x_{ik} : ith data on the kth variable

x_{jk} : jth data in kth variable

n : number of variables

d. Group each data based on the closest distance to the centroid.
e. Determine the new centroid value by calculating the average of the data in the cluster using the formula:
f. Recalculate the distance of each data to the new centroid. If the cluster changes, then repeat steps b to f. If the cluster has not changed, then the iteration is stopped.

Results and Discussion

After the data collection process, descriptive statistical tests were carried out looking at the general picture of the data. The results of descriptive statistical tests can be seen in table 2.

Table 2. Descriptive Statistical Test Results

Type of Errors	N	Minimum	Maximum	Mean
Reading	216	0	12	4.36
Comprehension	216	0	12	6.49
Transformation	216	0	12	8.93
Process Skill	216	0	12	9.21
Encoding	216	0	12	8.26

Based on the results of descriptive statistical tests in table 2, there were 216 students analyzed. In the reading variable, the minimum score is 0. So it can be interpreted that there are students who successfully complete all the questions without making reading errors. On the other hand, the maximum score on this variable is 12. So it can be interpreted that there are students who do not write down the information given in the questions at all, but there are also students who succeed in doing the reading part correctly. This also occurs with the other four types of errors. So it can be said that there are students who succeed in doing their work without making errors, but there are students who don't write down answers at all.

K-Means Clustering Process

In this research, cluster analysis will be carried out using the k-means method to group students based on the errors made when solving linear programming problems. The analysis steps with k-means clustering are as follows:

1. Determine the number of clusters (k clusters).
   Based on the dendogram results, the optimal number of clusters to be used is two.
2. Determine the initial cluster center point or initial centroid randomly.

The initial centroid in this process was chosen randomly using SPSS software with an initial number of centroids of 2 for each variable, according to the number of clusters that had been determined. The following are the initial centroids used:

Table 3. The Initial Centroid

Centroid	**X1**	**X2**	**X3**	**X4**	**X5**
C1	12	12	12	12	11
C2	0	0	2	0	0

3. Calculate the distance of each data to the initial centroid.
   Calculate the distance of each data to the initial centroid using Euclidean Distance. The following is an example of the calculation on the 1st data (Respondent 1) for each centroid:

   $$d_{(c1)} = \sqrt{(6-12)^2 + (11-12)^2 + (8-12)^2 + (12-12)^2 + (12-11)^2}$$

   $$= 7.348469228 \approx 7.348$$

   $$d_{(c2)} = \sqrt{(6-0)^2 + (11-0)^2 + (8-2)^2 + (12-0)^2 + (12-0)^2}$$

   $$= 21.9317122 \approx 21.932$$

   After calculating the distance for each data, then look for the minimum distance at C1 and C2. Determination of clusters is seen based on the minimum distance to C1 and C2. According to MacQueen, if the minimum distance is at C1, then the student is included in the cluster (MacQueen, 1967). If the minimum distance is at C2, then the student is included in cluster 2.

4. Calculate the new centroid value with cluster membership in the first iteration.
   Based on the results of the clusters formed, cluster 1 contains 176 students, and cluster 2 contains 40 students. After cluster membership has been formed in the first iteration, the next step is to determine the new centroid for the second iteration. Determining a new centroid aims to check whether the cluster results in the next iteration have changed or not. The new centroid is obtained by calculating the average of the data in each cluster formed.

Centroid	X1	X2	X3	X4	X5
C1	4.795	7.432	9.716	10.290	9.460
C2	2.450	2.325	5.450	4.475	2.975

After getting the new centroid, the next step is to carry out the second iteration, namely recalculating the distance of each data to the new centroid as in the first iteration.

5. Recalculate the distance of each data to the new centroid. If the cluster has not changed, then the iteration is stopped.
   The iteration process on student data was carried out 3 times. This is because the members of each cluster in the 3rd iteration did not change. The results of student grouping are shown in the following scatter plot:

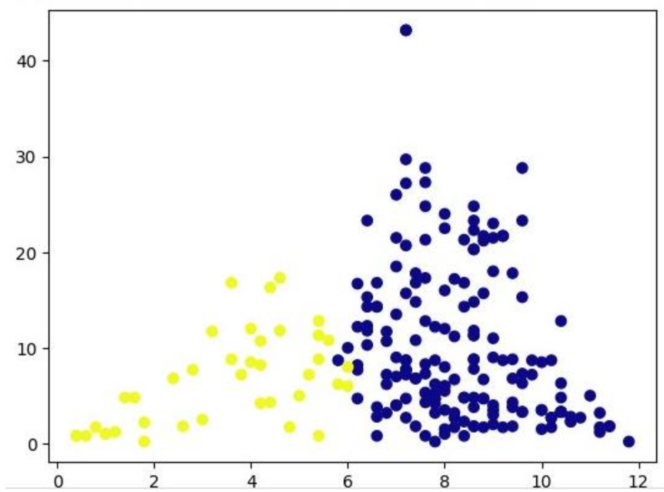

Figure 3. Scatter Plot of Student Grouping Results

In figure 3, students are grouped into two groups, namely the yellow and blue groups. Cluster 1 members are represented in blue, while cluster 2 members are represented in yellow. The x-axis is the average student error score and the y-axis is the variance value. Based on that figure, it can be seen that students in cluster 1 have a higher average error score compared to students in cluster 2. The number of members in each cluster is listed in the following table:

Table 4. Number of Members in Each Cluster

Cluster	Count
1	177

2	39

The table above provides information about the number of members in each cluster. Cluster 1 consists of 177 members and cluster 2 consists of 39 members.

The characteristics or characteristics of each cluster that has been formed will be defined by calculating the average value of the variables in each cluster and the difference between the average value of the variables in each cluster and the average value of the variables in the entire population. Following are the results of calculating the average value of each variable in each cluster:

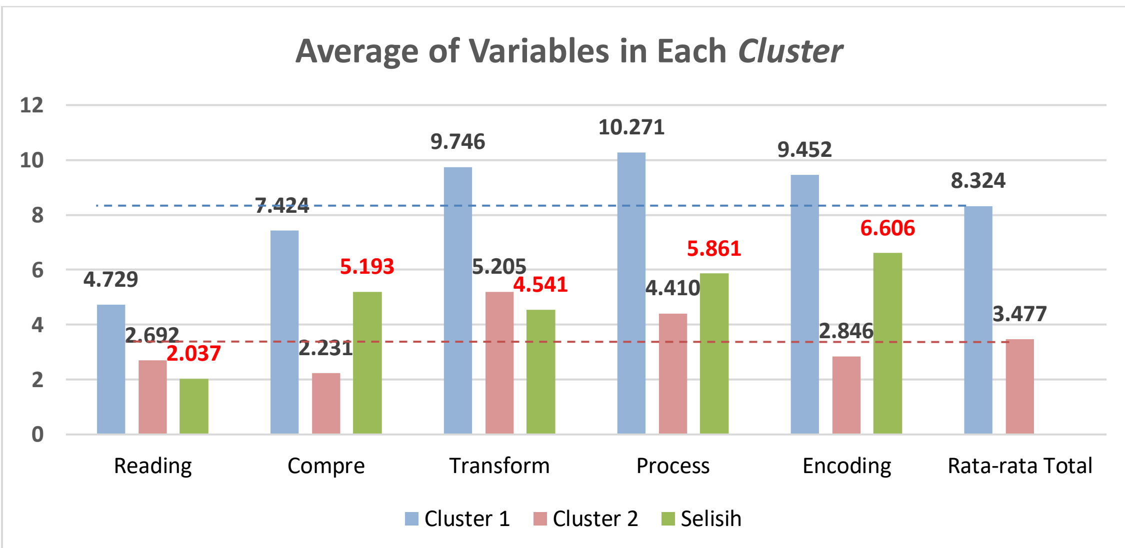

Figure 4. Average of Variables in Each Cluster

Based on the results of the average calculation in Figure 4, the average of all variables in cluster 1 is greater than the average of variables in cluster 2. On the other hand, the average of all variables in cluster 2 is smaller than the average of variables in cluster 1. So it can be concluded that students in cluster 1 make more mistakes when solving linear programming problems. Based on Figure 4, cluster 1 has three types of errors that are above the total average, namely transformation errors, process skill errors, and encoding errors. This indicates that in cluster 1, the types of errors that dominate are transformation errors, process skill errors, and encoding errors. Cluster 2 has two types of errors that are above the total average, namely transformation errors and process skill errors. This indicates that in cluster 2, the types of errors that dominate are transformation errors and process skill errors.

Next, the researcher compared the average value of the variable in each cluster with the average value of the variable for the entire population. The following is the average value of the variables in each cluster which has been reduced to the population average:

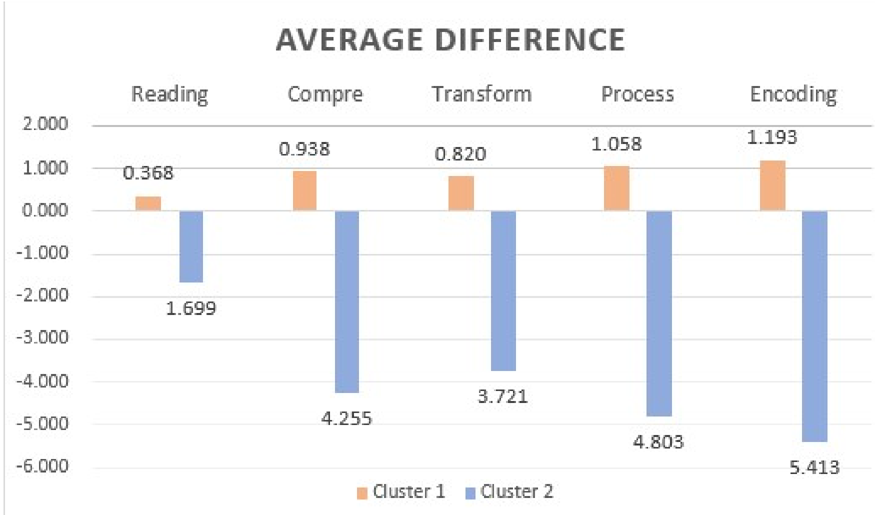

Figure 5. Difference between the Average Value of the Variable in Each Cluster and the Population Average

Based on Figure 5, the information shown is that the average value of all variables in cluster 1 is above the population average. In contrast to cluster 1, the average value of all variables in cluster 2 is below the population average. This proves again that it is true that students in cluster 1 made more errors than those in cluster 2.

Based on the results of the interpretation of figures 4 and 5, the characteristics of each cluster formed were obtained. The following is an explanation of the characteristics of each cluster:

- Cluster 1 has the characteristic "high error rate" which is characterized by the highest average value for all types of errors when compared with cluster 2. The types of errors that dominate in cluster 1 are transformation errors, process skill errors, and encoding errors. In addition, the average value of all types of errors in cluster 1 is above the population average value. In table 4.7, information on the number of members in each cluster is given. Cluster 1 consists of 177 students. Based on these data, it can be concluded that as many as 177 out of 216 students had a high error rate when solving linear programming problems.
- Cluster 2 has the characteristic "low error rate" which is characterized by the lowest average value for all types of errors when compared with cluster 1. The types of errors that dominate in cluster 2 are transformation errors and process skill errors. In addition, the average value of all types of errors in cluster 2 is below the population average value. In cluster 2, error scores vary more in the types of errors, transformation error and process skill error. Cluster 2 consists of 39 students. Based on this data, it can be concluded that 39 out of 216 students had a low error rate when solving linear programming problems.

A comparison of the types of errors made between cluster 1 and cluster 2 students can be seen in this part. Comprehension error is an error that students make when they are not able to write the objective function correctly. There are still many students who make this error, especially students in cluster 1. The following are examples of comprehension errors made by students in cluster 1 and cluster 2:

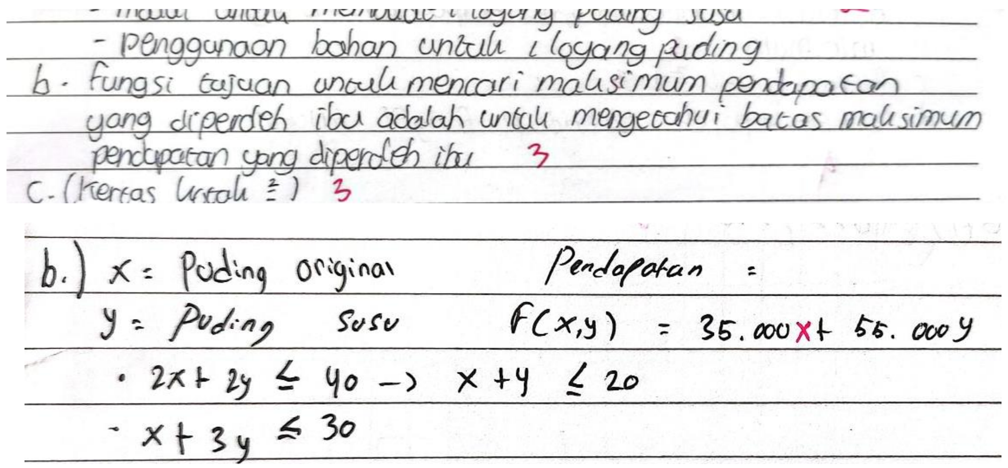

Figure 6. Respondent Worksheet 21 and 30 on Variable X_2

Based on the worksheet of respondent 21 who was included in cluster 1, students did not understand how to determine the objective function to seek maximum income so students did not write down the objective function at all. Meanwhile, the results of the work of 30 respondents who are included in cluster 2, students already understand the strategy for calculating maximum income, namely the selling price multiplied by the number of cakes sold. However, respondent 30 was not careful by not writing x in the objective function. From the error scores, it can be seen that students in cluster 1 have higher error scores compared to students in cluster 2.

Transformation Error is an error that students make when they are not able to transform linear inequalities into graphic form correctly. Many students make mistakes when drawing solution graphs. The following are examples of transformation errors made by students in cluster 1 and cluster 2:

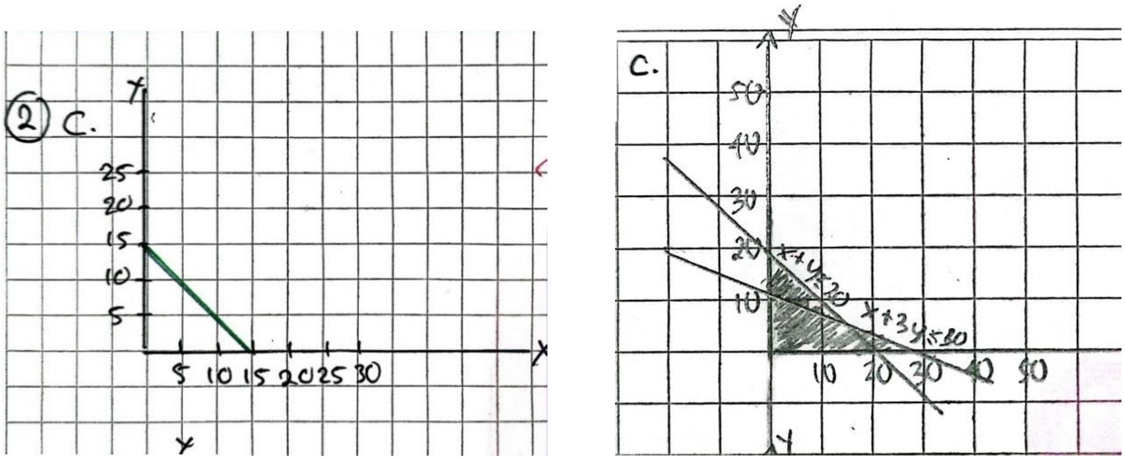

Figure 7. Respondent Worksheet 57 and 3 on Variable X_3

Based on the work of respondent 57 who is included in cluster 1, students do not understand how to make a line on a graph of an inequality. Therefore, students cannot draw the solution graph correctly. Meanwhile, the results of the work of respondent 3, which is included in cluster 2, show that students have been able to transform inequalities into lines in Cartesian coordinates correctly. Students have also shaded the area through which each line passes. However, students do not determine the area that is the solution to the graph. From the error scores, it can be seen that students in cluster 1 have higher error scores compared to students in cluster 2.

Process Skill Error is an error that students make when they are not able to carry out the corner point test correctly. In cluster 1, many students have high error scores on the process skill variable. This indicates that many students still make mistakes when carrying out the corner point test. The following are examples of process skill errors made by students in cluster 1 and cluster 2:

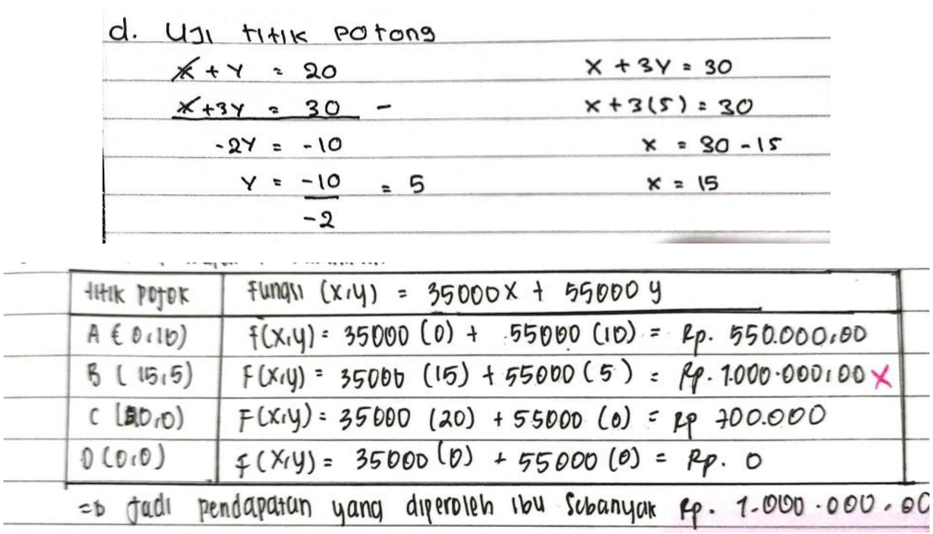

Figure 8. Respondent Worksheet 21 and 5 on Variable X_4

Based on the work of respondent 21 who is included in cluster 1, students did not test the corner points of the objective function, but only calculated the intersection points of the two inequality lines. Meanwhile, in the work of respondent 5, who is included in cluster 2, the student was able to test all corner points, but only made a mistake in calculating the product of the coordinate point and the objective function.

Encoding Error is an error made by students when they are not able to change the answer they have obtained to its initial form. There are still many students who have high error scores on this variable. The following are examples of encoding errors made by students in cluster 1 and cluster 2:

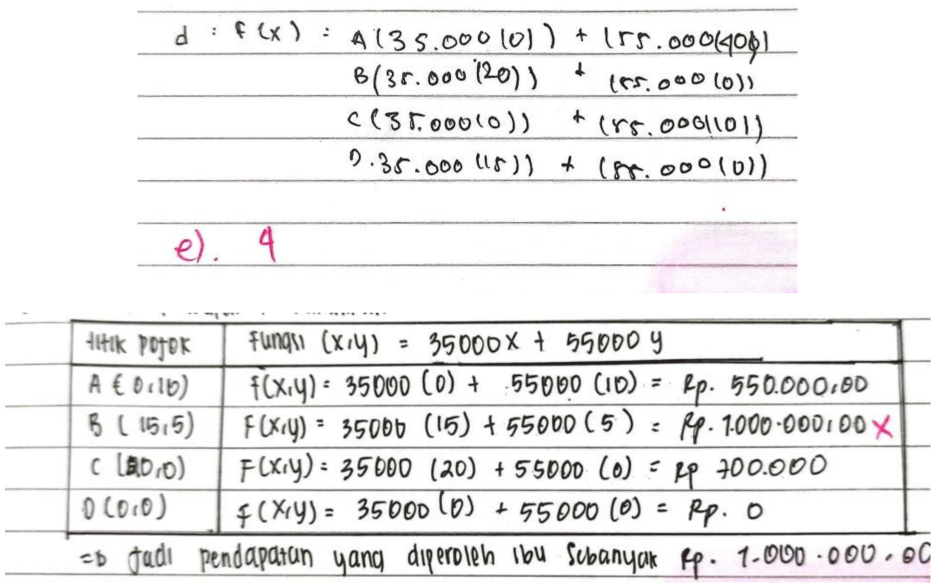

Figure 9. Respondent Worksheet 80 and 5 on Variable X_5

Based on the work of 80 respondents who were included in cluster 1, students did not give a final answer at all after carrying out the corner point test. Students stop until the corner point test stage. Meanwhile, in the work results of respondent 5, which is included in cluster 2, the student was correct in choosing the final answer and interpreted the answer as the income earned. Students just don't write the maximum word when interpreting the answer.

The results of the comparison between the two clusters provide information that the score of errors made by students in cluster 1 is greater when compared to students in cluster 2. Based on Figure 4, transformation errors and process skill errors are the two types of errors that dominate in both clusters.

Next, researchers want to know the types of errors that are significant in distinguishing each cluster. Researchers use discriminant analysis to determine the types of errors that significantly differentiate clusters. The results of the discriminant analysis can be seen in the Canonical Discriminant Function Coefficients table. The types of errors included in table 4 are the variables that contribute most to differentiating each cluster.

Table 5. Canonical Discriminant Function Coefficients

	Function 1
Compre	0.139
Transform	0.115
Process	0.161
Encoding	0.247
(Constant)	-5.451

Based on table 4, there are four types of errors that are included in the discriminant function. Reading errors are not included in the discriminant function table. This indicates that reading error is weak in distinguishing the clusters formed. So, there are four types of errors that contribute most to differentiating groups, namely comprehension errors, transformation errors, process skill errors, and encoding errors.

Conclusion

The results of the study showed that all grade X students at SMAN 9 Jakarta still made mistakes when solving linear programming problems. There are still no students who are able to work on problems without making mistakes. In this study, students were grouped based on the types of errors made. Based on the results of grouping using the k-means clustering method, there were 177 students who were included in cluster 1 and 39 students who were included in cluster 2. Cluster 1 has the characteristic of a "high error rate" which is marked by the highest average score on all types of errors when compared to cluster 2. In addition, the average score of all types of errors in cluster 1 is below the average value of the population. The types of errors that dominate in cluster 1 are transformation errors, process skill errors, and encoding errors. So it can be concluded that as many as 177 out of 216 students have a high error rate when solving linear programming problems. Cluster 2 has the characteristic of a "low error rate" which is marked by the lowest average score on all types of errors when compared to cluster 1. In addition, the average score of all types of errors in cluster 2 is above the average value of the population. The types of errors that dominate in cluster 2 are transformation errors and process skill errors. So it can be concluded that as many as 39 out of 216 students have a low error rate when solving linear programming problems. The types of errors that contribute significantly to distinguishing each cluster are comprehension errors, transformation errors, process skill errors, and encoding errors. The results of the study showed that most students were in the cluster with a high error rate. This can indicate that most students still do not understand the linear programming material well.

Therefore, the results of the study obtained can be used as evaluation material for teachers to improve students' understanding of linear programming material. The results of this study can also be used as a reference and evaluation material to see in what steps of the solution students make many mistakes, so that teachers can maximize their teaching for the next class.

References

Amanda Hidayah, A., Harahap, E., & Badruzzaman, F. H. (2022). Optimasi Keuntungan Bisnis Bakery Menggunakan Program Linear Metode Simpleks. *Jurnal Matematika*, *21*(1). https://journals.unisba.ac.id/index.php/Matematika

Asy'ari, M. F., Siswono, T. Y. E., & Lukito, A. (2020). Kompetensi Strategis Siswa dalam Menyelesaikan Persoalan Program Linear Ditinjau dari Kecemasan Matematika. *Math Didactic: Jurnal Pendidikan Matematika*, *6*(1), 98–109. https://doi.org/10.33654/math.v6i1.916

Ghozali, I. (2021). *Aplikasi Analisis Multivariate dengan Program IBM SPSS 26* (10th ed.). Badan Penerbit Universitas Diponegoro.

Grossman, D. A., & Frieder, O. (2004). *Information Retrieval: Algorithms and Heuristics*. Springer Netherlands. https://doi.org/10.1007/978-1-4020-3005-5

Hasana, H. R., Rifandi, R., Tasman, F., & Jamaan, E. Z. (2022). DESKRIPSI KEMAMPUAN BERPIKIR KRITIS PESERTA DIDIK KELAS XI IPS PADA TOPIK PROGRAM LINIER. *Jurnal Equation: Teori Dan Penelitian Pendidikan Matematika*, *5*(2), 77–84.

Laelasari, I. (2021). Analysis of the Implementation of Technology-based Outdoor Learning Model in Science Subject (Plant Diversity) Analisis Penerapan Strategi Pembelajaran Daring Dengan Model Outdoor Learning Berbasis Teknologi Pada Pembelajaran IPA (Keragaman Tumbuhan). *Elementary*, *7*(1), 14–25.

Muliono, R., & Sembiring, Z. (2019). *DATA MINING CLUSTERING MENGGUNAKAN ALGORITMA K-MEANS UNTUK KLASTERISASI TINGKAT TRIDARMA PENGAJARAN DOSEN*. *4*(2), 272–279.

Musfiani. (2019). ANALISIS CLUSTER DENGAN MENGGUNAKAN METODE PARTISI PADA PENGGUNA ALAT KONTRASEPSI DI KALIMANTAN BARAT. *Buletin Ilmiah Math. Stat. Dan Terapannya (Bimaster)*, *08*(4), 893–902.

Ningsi, G. P., Nendi, F., Jehadus, E., Sugiarti, L., & Kurnila, V. S. (2022). Analisis Kesalahan Mahasiswa dalam Menyelesaikan Soal Kalkulus Integral Berdasarkan Newman's Error

Analysis dan Upaya Pemberian Scaffolding. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *6*(3), 2698–2712. https://doi.org/10.31004/cendekia.v6i3.1469

Rindengan, A. J., & Langi, Y. A. R. (2018). *PROGRAM LINEAR*. CV. Patra Media Grafindo.

Sadiah, L. H., Juandi, D., & Herman, T. (2023). Kemampuan Siswa dalam Memecahkan Masalah Program Linear: Sistematik Literatur Review. *Jurnal Pembelajaran Matematika Inovatif*, *6*(4), 1523–1536. https://doi.org/10.22460/jpmi.v6i4.17639

Susanto, D., Kurniawan, T., Sihombing, S. K., Salim, E., Radjawane, M. M., Salmah, U., & Wardani, A. K. (2021). *Buku Panduan Guru Matematika untuk SMA/SMK Kelas X* (T. Hartini, Ed.; 1st ed.). Pusat Kurikulum dan Perbukuan Badan Penelitian dan Pengembangan dan Perbukuan Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.