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The Analysis of Students' Error in Operation Reseach Test for Linear Program Topic Based on Newman's Error Analysis (NEA)

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Abstract. This study aims to analyze the types of error and its factors that cause students' error in solving operation research problems in the program linear topic based on Newman's Error Analysis (NEA). This research is qualitative research by using a descriptive approach. The subjects in this study are fourth-grade college students in the Mathematics Education Program at State Islamic Institute of Kerinci that chosen by purposive sampling technique. The data was collected by using a test and interview. The data analysis was done descriptively. Based on the research findings, the types of students error in solving operation research problems were reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors. The factors that cause the students' error were the students can not interpret, understand and understand the meaning of the questions overall; can not determine the formula to solve the problems; can not carry out the algorithm of arithmetic operations.

Keywords: Error Analysis; Newman's Error Analysis; Operation Research

Abstrak. Penelitian ini bertujuan untuk menganalisis jenis kesalahan dan faktor yang menyebabkan kesalahan mahasiswa dalam menyelesaikan soal riset operasi pada materi program linier berdasarkan Newman's Error Analysis (NEA). Penelitian ini merupakan penelitian kualitatif dengan menggunakan pendekatan deskriptif. Subjek penelitian ini adalah mahasiswa semester IV program studi Tadris Matematika IAIN Kerinci tahun akademik 2018/2019 yang dipilih dengan teknik *purposive sampling*. Data dikumpulkan melalui tes dan wawancara dan dianalisis secara deskriptif. Berdasarkan temuan penelitian diketahui bahwa jenis kesalahan mahasiswa dalam menyelesaiakan soal riset operasi materi program linier berdasarkan Newman's Error Analysis adalah kesalahan dalam membaca soal, kesalahan dalam memahami masalah, kesalahan dalam transformasi, kesalahan dalam keterampilan proses, dan kesalahan dalam penulisan jawaban akhir. Faktor-faktor penyebab kesalahan tersebut meliputi: mahasiswa tidak bisa memaknai, mengerti dan memahami makna keseluruhan dari soal yang berikan; tidak bisa menentukan rumus yang digunakan; dan tidak bisa menajalankan tahapan-tahapan operasi hitung yang digunakan untuk menyelesaikan soal.

Kata kunci: Analisis Kesalahan; Newman's Error Analysis; Riset Operasi

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INTRODUCTION

Mathematics is a science that plays an important role in life which has a character as an abstract science. With mathematics, the ability to think logically, critically, analytically, creatively, and productively can be developed. Mathematics is also a basic science that has an important role in the development of science and technology. Therefore, mathematics was taught at all levels of school, from elementary to university. One of the branches of mathematics is Operations Research. According to Miller and Star, operations research is a management tool that brings together science, mathematics, and logic in optimally solving daily problems (Aminudin, 2005). Operations research began to develop even before World War II, one of the earliest British groups to introduce Operations Research led by Blackeet. In line with the development of world progress, Operations Research is increasingly being used and applied in various fields, namely in accounting and finance, marketing, production operations, and other fields.

Operations Research at the university level is not only found in mathematics or mathematics education study programs but also in other courses such as economics, management, and engineering. Operations Research is a subject that must be taken by students of the Mathematics Education Study Program in IAIN Kerinci, which consists of 2 credits. One of the topics contained in the Operations Research course is the linear program. Linear programming is an analytical planning technique whose analysis uses a mathematical model to find several alternative combinations of optimum solutions to problems (Aminudin, 2005). The method of solving problems in linear programming is the graphical method and the simplex method, each of which contains steps in the solution.

This linear program topic is the initial topic of Operations Research and one of the most widely applied models as well as the core of Operations Research so that a good understanding of the concept in this topic must be possessed by students. Students can be said to have the ability to understand mathematical concepts if they can formulate a solution strategy well, can apply simple calculations, and can present concepts using mathematical symbols correctly, and change one form to another such as fractions in mathematics learning (Susanto, 2015). The process of solving problems in this linear program topic goes through several stages in which if an error occurs, the next stage will experience an error so that the final result is wrong. Therefore it is deemed necessary to know and analyze student errors in solving and solving given problems so that learning for the further topic can be more optimal.

Based on interviews with one of the lecturers in the Mathematical Operations Research course at IAIN Kerinci, it is known that students get the final score of the linear program topic test which is still relatively low because students do many errors in the problem-solving process. The

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process of problem-solving needs to be analyzed in more depth to know the types of students' errors and their causes. The method used to analyze the errors is Newman's Error Analysis (NEA). NEA is a method introduced by M. Anne Newman in 1977. According to Newman, NEA is a framework with simple diagnostic procedures, which include reading, comprehension, transformation, process skills, and. Therefore the types of errors based on the Newman procedure are reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors (errors in writing answers) (Singh, Rahman & Hoon, 2010; Susanti, 2019).

Several previous studies have revealed students errors based on Newman's Error Analysis (NEA), especially statistical topics (Dirgantoro, Saragih & Listiani, 2019), inequality and limit functions (Erdriani & Devita, 2019), calculus for many variables (Farhan & Zulkarnain, 2019), vector analysis (Jana, 2018), analytic geometry (Junaedi, 2012), geometric shapes (Listiani, Dirgantoro, Saragih & Tamba, 2019; Mulyadi, Riyadi & Subanti, 2015), discrete mathematics (Oktaviana, 2017), plan geometry (Utami, 2016; Pamungkas & Wicaksono, 2019), differential calculus (Rahmawati, 2017), and algebra (Yusnia & Fitriyani, 2017). The results of this study indicate that generally, the most mistakes made by research subjects are errors in the transformation stage, errors in the process skills stage, errors in writing the final answer, and errors in understanding the problem. However, error analysis in the Operations Research course on the linear program topic has not been a concern in research.

Therefore, researchers are interested in exploring more deeply about student errors in solving Operations Research questions for linear program topic based on Newman's Error Analysis (NEA), so that both lecturers and students can find out where students' mistakes are in solving specific problems, students can be more motivated and more be careful in the process of problem-solving, as well as for lecturers to become attention and improve learning in the next topic.

METHOD

This research is qualitative research using a descriptive approach. The research subjects involved in this study were students of the fourth-semester of the Mathematics Education Study Program in IAIN Kerinci in the academic year 2018/2019 who were selected by a purposive sampling technique. The research subjects consisted of 28 students who were given a written test that consist of 2 questions. The test instrument used was validated by two Mathematics Education lecturers at IAIN Kerinci to obtain a valid instrument.

After the test was carried out, the researcher evaluated the results of the answers to identify the mistakes that were made by the students in their answers. Then the researcher conducted unstructured interviews with 5 students who represented each type of error. To explore the constraints, problems, and causes of students' error in solving the questions on a linear program

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topic, the researcher developed questions during the interview process so that the interviews took place as in everyday conversation. The stages of data analysis in this study are data reduction, data presentation, and verification (Sugiyono, 2016). Meanwhile, at the data validity check stage, triangulation techniques are used. The type of triangulation used is source triangulation by comparing student work data with interviews.

RESULTS AND DISCUSSION

Before implementing the test, students are asked to study or repeat the linear program topic that has been studied in the hope that the test results can describe the student's true abilities.

Types of Student Errors in Completing Operations Research Questions on Linear Program Topic Based on Newman's Error Analysis (NEA)

Based on the results of examining the student answer sheets, it was found that various forms of errors were found in solving the linear program topic questions. The distribution of the types of errors experienced by students is presented in Table 1. In Table 1, M is for types of reading errors, P is for types of comprehension errors, T is for types of transformation errors, K is for types of process skills errors, J for the types of encoding errors, and B if no errors were found.

Table 1. The Type of Students' Errors

Type of Errors	The Students' Who did Errors	
	Question 1	Question 2
M	M5, M13, M15, M16, M19, M24, M25, M26, M27	M5, M13, M15, M16, M19, M24, M25, M26, M27
P	M5, M8, M9, M11, M13, M15, M16, M17, M19, M23, M24, M25, M26, M27	M5, M8, M9, M11, M13, M15, M16, M17, M19, M23, M24, M25, M26, M27
T	M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12, M13, M15, M16, M17, M18, M19, M20, M21, M23, M24, M25, M26, M27, M28	M5, M6, M7, M8, M9, M10, M11, M12, M13, M15, M16, M17, M19, M23, M24, M25, M26, M27
K	M2, M5, M8, M9, M11, M13, M17, M19, M21, M23, M24, M25, M26, M27, M28	M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12, M13, M14, M15, M16, M17, M18, M19, M20, M21, M23, M24, M25, M26, M27, M28
J	M2, M17, M20, M24	M2, M17, M20, M24
B	M14, M22	M22

In Table 1, it can be seen that at the reading error stage there were 8 students having difficulty in question 1 and 9 students having difficulty in question 2. In this case, students have not been able to interpret the sentences they read correctly. At the comprehension errors stage, there were 14 students having difficulty on question 1 and 14 students having difficulty on question 2. In

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this case, they did not understand what was known and was stated in the question well. In the transformation phase, there were 26 students having difficulty with question 1 and 18 students having difficulty with problem number 2. Students were unable to plan solutions to work on problems and were wrong in determining mathematical formulas and operations. At the process skills error stage, there were 15 students having difficulty on question 1 and 27 students having difficulty on question 2. Students did not perform arithmetic operations correctly and did not realize that they had made a mistake in the calculation operation performed. At the encoding errors stage, 4 students made mistakes on number 1 and 4 students made mistakes on number 2. Students wrote down the final answers that did not match the context of the questions and some students did not write down the final answers.

The types of misunderstanding, transformation errors, and processing skills errors were the most common mistakes experienced by students. Errors in the understanding stage have an impact on the transformation of the problem and the improper resolution process (Utami, 2016). The error in writing the final answer did not seem dominant because only students who wrote the final answer were judged. Meanwhile, not all students who completed the questions also wrote their final answers. In Table 2, the percentage of students who experience each type of error is presented in proportion to the total number of students.

Table 2. Percentage of Students' Errors

Type of Errors	Number of Students	Percentage
Reading Errors (M)	7	25%
Comprehension Errors (P)	14	50%
Transformation Errors (T)	26	92,86%
Process Skills Errors (K)	27	96,43%
Encoding Errors (J)	4	14,29%

In Table 2, it can be seen that the most difficulties experienced by students occur at the transformation and process stages. This is related to the reading and understanding stages. If students are not able to interpret the sentences they read correctly then they cannot write what is known and stated in the questions correctly so they cannot plan solving strategy and cannot determine the formula that will be used. This is in accordance with the results of research by Yusnia & Fitriyani (2017) that the percentage of students who make mistakes in the problem transformation stage and the process skills stage is more dominant.

Student Errors at the Reading Stage

At the reading stage, there are 25% of students having difficulty going through the reading stage well, even though students can read the questions well and correctly. This is due to the form

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of the questions is a story problem that uses good Indonesian. The words or sentences used in the questions also do not use foreign terms or languages that complicate and confuse students. However, it turns out that there are still students who are unable to interpret the sentences they read correctly.

Student Errors at the Comprehension Stage

At the understanding stage, 50% of students made mistakes. Based on the results of tests and interviews conducted on question 2, some students did not understand the meaning of the questions and could not write down what was known completely, this was because the previous students could not find the keywords contained in these sentences so that difficulty in the next stage. When determining the variables in the objective function and constraint function, some students do not write and make what is known in advance into a table, which is presented in a table that makes it easier to understand the meaning of the question.

Student Errors at the Transformation Stage

Errors in the transformation stage in the NEA are errors in planning solutions or methods of solving, errors in determining formulas, and errors in mathematical operations. At this stage, there were 92.86% of students did errors which were the most error stages committed by students. The dominant error at the transformation stage was also revealed by previous research (Mulyadi, Riyadi & Subanti, 2015).

Student Errors in the Process Skills Stage

At the process skills stage, there were 96.43% of students who did errors. Error in processing skills is a student's mistake in performing arithmetic operations correctly and students are not aware of making mistakes in the count operations performed. In this study, most students were not able to carry out the stages of the counting operation used so that some of the students in question 2 were constrained by the calculation process of finding the ratio of the quantity, key line elements, and new key line so that some of them did not complete the calculation until it was finished. This condition was also expressed in the research of Mulyadi, Riyadi & Subanti (2015).

Student Errors at the Encoding Stage

At the stage of writing the final answer, there were 14.29% of students experiencing errors, because students wrote the final answers that did not match the context of the questions and some students did not write the final answers. This is in accordance with the results of research by Fitriani, Turmudi & Prabawanto (2018) which only found 6.1% of students made errors during the encoding errors, but most of the research subjects did not write down the conclusions of the answers and could not prove the truth of their answers.

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The Cause Factors of Student Errors in Completing Research Operations Questions on the Linear Program Topic

The factors that cause student errors in solving Operations Research questions on the linear program material at each stage of working on the questions tend to vary. The results of in-depth interviews with M2, the student experienced errors in the transformation stage, process skills, and the writing of the final answer, stated that he could not carry out the transformation stage, namely in the process of drawing graphics with unclear intersection points between graphs, and the process of elimination and substitution on question 1, then he did not know the formula that should be used in solving problem 2, namely the simplex method in the process of determining a new line beside the key line and also he was wrong in mathematical arithmetic operations, and he also could not interpret the final answer in the form of a sentence.

The results of the researcher's interview with M5, the student experienced errors in reading, understanding, transformation, and process skills, revealed that he did not understand the meaning of the question, he could not write down what he knew completely, then he could not use the method to solve the questions correctly, both in question 1, namely the graph method and question 2, namely the simplex method, so that he was wrong in getting the result of solving the problem. In the calculation process, he also do an error in performing arithmetic operations, so it can be concluded that the student was also unable to operate correctly. Meanwhile, M14, only students who experienced errors in process skills did not realize that they had made mistakes in arithmetic operations. M14 states that in question 2 at the stage of finding the quantity ratio, he does not get the result so he does not get the correct final result.

The results of the interview with M17 showed that students did errors in the stages of understanding, transformation, processing skills, and writing the final answer, not much different from M5. M17 also stated that he did not understand the meaning of the problem, in question 2 he could not write down what was known completely, then he could not use the method to solve the problem correctly, especially in question 2, namely the simplex method, so he was wrong in getting the result of solving question 2. In the calculation process, he also did an error in performing a counting operation, so it can be concluded that the student was also unable to operate correctly and he also had difficulty interpreting the final answer in the form of a sentence. The results of the interview with M28, the student did errors in the stage of transformation and process skills, stating that in question 1 he was not good at drawing graphics. Whereas in question 2, he was confused at the arithmetic operation stage to determine the elements in the transformation table of the simplex method. In stage 3, so that he cannot complete the answer completely and does not get the final result that the question wants.

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Errors in reading questions are caused by ignorance of the subject to the concept of the topic. Generally, the subject can read properly and correctly but cannot interpret the sentences in the questions (Mulyadi, Riyadi & Subanti (2015). Errors in reading questions can also occur because students do not understand the meaning of the questions or cannot interpret the keywords contained in the question. Meanwhile, errors in understanding are generally caused by the subject to understand the context of the problem but cannot write down the meaning correctly, are not thorough, do not understand the meaning of the whole problem properly so that it is inconsistent in identifying what is known, and lacks appropriately captures the information contained in the questions (Yusnia & Fitriyani, 2017) In line with this, in this study the error was caused by students not understanding the overall meaning of the questions given and students unable to write down what was known and asked about the questions.

Transformation errors occur because students cannot determine the formula that will be used to solve the problem and students cannot determine the mathematical operation or series of operations to solve the problems contained in the problem correctly. Also, it is because students cannot identify operations or a series of operations. Whereas the cause of errors in process skills is that students do not know the process/algorithm for solving the questions even though they can determine the formula correctly and students have difficulty carrying out the stages of calculating operations used to solve these questions (Mulyadi, Riyadi & Subanti, 2015). In line with Utami (2016), errors in process skills are also due to students having difficulty manipulating calculations. Errors in writing answers are caused by students not being able to express the solution in the form of a written sentence that matches the purpose of the question.

CONCLUSIONS

Based on the results of results and discussions, it can be concluded that the types of student errors in completing operational research questions on linear program topics based on Newman Error Analysis are reading errors, comprehension errors, transformation errors, process skills errors, and encoding errors. While, the factors causing student errors in solving operational research questions of the linear program topic include difficulties in interpreting, understanding, and understanding the overall meaning of the questions given; difficulty in determining the formula to be used; and difficulties in carrying out the stages of arithmetic operations used to solve problems. Lecturers need to emphasize an understanding of the process skills errors as well as the transformation errors by giving students lots of practice so that students can be trained so that they can be careful and thorough. In addition, lecturers need to provide a variety of questions or problems in a contextual manner so that students are familiar with the questions in the form of stories so that students can easily understand the meaning of the questions. Finally, lecturers should

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be more structured in explaining examples of problem-solving to form good problem-solving patterns for students.

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