



ANALYSIS OF STUDENT ERROR IN SOLVING FUNDAMENTAL METHOD OF COUNTING BASED ON NEWMAN'S THEORY

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Abstract

The purpose of this study was to find out: (1) what types of errors were made by students in solving questions on the fundamental method of counting, (2) what factors caused students to make mistakes in solving questions on the fundamental method of counting. This study used descriptive qualitative method. The subject of this research is Informatics Engineering students. Data collection using test, interview, and documentation. Data analysis techniques include the stages of data reduction, data presentation, and drawing conclusions. In this study, student errors were analyzed based on Newman's five error indicators, (a) reading error, (b) comprehension error, (c) transformation error, (d) process skills error, and (e) encoding error. Based on the analysis, it was found that the most errors made by students in solving fundamental method of counting were comprehension error and process skills error. The two errors caused the writing of the final answer to be wrong.

Keywords: error analysis; the fundamental method of enumeration; Newman's theory

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INTRODUCTION

Discrete Mathematics is one of the courses studied in college. One of the materials in Discrete Mathematics is the Fundamental Method of Enumeration, where in this material it discusses the basic principles in enumeration (multiplication rules and summation rules), permutations, combinations, binomial coefficients and pascal triangles, as well as the bird cage principle.

The fundamental method of enumeration is very important because this material discusses how to find the possibility of the multiplicity of events, either by using the method of filling slots, or using the rules of permutation and combination. The fundamental method of enumeration, especially permutation and combination



materials, is familiar to students because this material has already been obtained in high school. Unfortunately, there are still many students who still experience difficulties or mistakes when doing questions related to permutations and combinations. Fourth semester students have difficulty in solving questions using permutations or combinations (Indriani, 2020), this difficulty is caused by several factors, one of which is the low ability to understand the subject matter so that they do not understand how to distinguish permutation questions and combination questions (Astuti, 2015).

Therefore, the purpose of this study is to analyze students' mistakes in doing the problem of the fundamental enumeration method. Analysis is the first step in the process of planning a learning (Gregory, 2010). Error analysis is a method, effort, or study commonly used to identify the cause of a student's mistake and to seek an explanation of the error (Fei Lai, 2012; Halim & Rasidah, 2019; Herholdt & Sapire, 2014). By knowing the mistakes of students in doing the fundamental method of enumeration, lecturers can find out where the student's mistakes lie and the causative factors. By knowing where the student's mistakes lie, lecturers can provide appropriate assistance to prevent students from making the same mistakes. In addition, this error analysis is also used as a reflection material and planning material for lecturers in teaching the fundamental method of enumeration. There are several methods in analyzing errors in solving mathematical problems, including (1) classifying errors based on conceptual errors and procedural errors (Prafianti, Dasari, & Jupri, 2018) and (2) classifying errors based on 5 indicators of Newman errors.

According to Newman, errors in doing math problems are divided into five, namely (1) reading errors, occurring because students are wrong in reading the main information questions so that students do not use the information in doing soal and make students' answers not in accordance with the intention of the questions; (2) comprehension error occurs because students do not understand, especially in the concept, students do not know what is actually asked about the problem and are wrong in capturing the information on the problem so that students



cannot solve the problem; (3) errors in transformation (transformation errors), occur because students have not been able to turn the problem into mathematical form correctly and incorrectly in using the sign of the counting operation; (4) errors in process skills (process skills errors), occur because students have not been skilled in performing calculations; (5) an error in the notation (encoding error), is an error in the settlement process (Clemen, 1980; Singh, Rahman, & Hoon, 2010; Trapsilo, 2016). As for the types of errors and error indicators according to Newman (Clemen, 1980) can be seen in the following Table 1.

Table 1. Newman Error Indicator

No	Error Type	Indicator
1	Reading Error	Students are wrong in reading terms, symbols, words or important information in the question
2	Comprehension Error	Students do not know what exactly is being asked about the question The error captures the information in the problem so that it cannot be completed to the next process.
3	Transformation Error	Students fail in changing to the correct form of mathematical model Students are wrong in using the sign of the count operation to solve the problem
4	Process Skill Error	Students are miscalculated Students do not continue with the completion procedure
5	Encoding Error	Students cannot write down the final answer requested by the question Students cannot infer answers



No	Error Type	Indicator
		according to math sentences Mistakes due to carelessness or lack of scrupulousness

In solving the problem of the fundamental method of enumeration in which there are problems of permutations and combinations, computational ability alone is not enough, because permutation problems and combinations are generally in the form of story questions that require analysis of the problem first before finding a solution (Mahyudi, 2016). In solving story problems, language skills also have an important role, the complexity of language has a significant effect on students' perceptions in solving story problems (Barbu, 2010).

METHOD

This research is a qualitative research and aims to describe students' mistakes in solving problems in the material of the fundamental enumeration method. The subjects in this study were 52 Informatics Engineering students in semester 1 class C of Lamongan Islamic University. The data collection methods used are test methods, interviews, and documentation. The instruments used in this study were the enumeration fundamental test and interview guidelines. The test instrument used is in the form of a material test question for the fundamental enumeration method which consists of 4 questions with basic principle material in enumeration, permutation, and combination. The following is a matter of the fundamental method of enumeration given to students.

1. A football team has:
 - a. White, blue, green, and red T-shirts
 - b. Black and white shorts
 - c. Red, black, and white socksHow many different uniform color combinations can be arranged? Give a few examples.
2. Ilham bought a suitcase equipped with a security lock code (password) in 3 numbers



- a. Is code 091 the same as code 019?
- b. How many codes can be generated if there can't be the same number?
- c. Why is a 3-number key code safer than a 2-digit one?
3. How many ways, if 3 people from the city of Surabaya, 4 people from Jakarta and 2 people from Bandung sit in one row so that the city sits side by side?
4. A swimming group of 21 swimmers. They assembled a competing team of 3 swimmers. How many possible team lineups can be formed?

Figure 1. Enumeration fundamental method test questions

Data analysis techniques include data reduction, data presentation, and drawing conclusions. The data collection procedure is detailed as follows, all class 1C students are asked to do the test questions for the fundamental enumeration method and then the student's answers are analyzed. After the student's answers are analyzed, the researcher groups the students' answers based on the mistakes made. From each mistake, one example was taken and an interview was conducted on the student concerned. The results of the test and subsequent interviews are presented and conclusions are drawn regarding the location of the error and the factors causing the error.

RESULT AND DISCUSSION

Data analysis was carried out by researchers based on the Newman error indicator (Clemen, 1980). The percentage size for each question in each type of error can be seen in Table 2 below.

Table 2. Student Answer Results for Each Question

No	Correct	False	Total
1	17	35	52
2	44	8	52
3	38	14	52
4	37	15	52
Sum	136	72	208
Percentage	65,38%	34,62%	100%

Table 2 shows that students who did not make mistakes were 65.38% while students who made mistakes were 34.62%. The most students made mistakes in



question number 1, namely 35 students and in question number 4, namely 15 students.

Furthermore, such errors are analyzed on the basis of Newman error indicators. The results of the analysis of student errors based on the Newman indicator are presented in Table 3.

Table 3. Percentage of Student Error based on Newman Indicators

No	Error Type	Problem			
		No 1	No 2	No 3	No 4
1	Reading	0	8	0	0
2	Understanding	35	0	0	1
3	Transformation	0	0	0	0
4	Processing	0	0	13	14
5	Notation	0	0	1	0
Errors Total		35	8	14	15

Table 3 shows that in question number 1 students experienced errors in understanding the questions as many as 35 people, in question number 2 students experienced errors in reading questions as many as 8 people, in question number 3 students experienced errors in process skills as many as 13 people and errors in notation as many as 1 person, while in question number 4 students experienced errors in understanding questions as many as 1 person and process skills errors (miscalculations) as many as 14 people.

From the results of data collection, one image is taken to represent the error in each question number.

1. Error at number 1

Based on the results of data collection, it was obtained that 35 students misunderstood the questions. Students doing question number 1 does not use the concept of multiplication rules. For example, students with the initials KF do the number one question not by multiplication rules but by factoring all known numbers as shown in Figure 2 below.



Handwritten student work for Figure 2:

$$\begin{aligned}
 \text{Kaos} &= 4! \\
 \text{Celana} &= 2! \\
 \text{Kaos kaki} &= 3! \\
 4! \times 2! \times 3! &= (4 \times 3 \times 2 \times 1) \times (2 \times 1) \times (3 \times 2 \times 1) \\
 &= 24 \times 2 \times 6 \\
 &= 288 \text{ kombinasi warna}
 \end{aligned}$$

Figure 2. Example of Error Type Understanding Problem Number 1

Based on the results of interviews with KF students, it is known that the error was because KF did not understand the questions. KF did not know what was actually asked about the question and was wrong in capturing the information on the question so that KF could not solve the problem. KF thinks that the many ways to choose a t-shirt of 4 pieces can be searched with $4!$, as well as the many ways to choose pants and socks. So that in this way the uniform color combinations that can be arranged are obtained 288 combinations. The correct answer is to use the multiplication rule, which is $4 \times 3 \times 2 = 24$. So there are 24 color combinations.

Handwritten student work for Figure 3:

A) Diker kaos putih, biru, hijau dan merah (4)

B) Celana hitam dan putih (2)

C) kaos kaki merah, hitam, dan putih (3)

Ditanya kombinasi Seragam :

$$\begin{aligned}
 n &= 4 + 2 + 3 = 9 \rightarrow = C(9,3) = n! \\
 &= \frac{9!}{(9-3)! \cdot 3!} = \frac{9 \times 8 \times 7 \times 6 \times 5 \times 4 \times 3}{6! \times 3!} = 504
 \end{aligned}$$

Figure 3. Example of Error Type Understanding Problem Number 1

Figure 3 shows another mistake of students in doing question number 1. Based on the results of interviews with SA students, it is known that the factor causing the error is because SA does not understand the concept. This is in accordance with research conducted by (Yanti, Hartono, & Somakim, 2016) which said errors in finding combinations because they did not understand the combinations and because of the similarity of questions. SA solves problem number



1 by combination because in the problem there is a combination word, namely "How many kinds of uniform color combinations can be arranged?"

2. Error at number 2

In question number 2, there were 8 students who were not careful in reading the questions, causing student answer errors. This is in accordance with Yensy (2018) research that says that students do not carefully read the questions so that they write down what is known incorrectly, use the wrong formula, miscalculate, and do not understand the meaning of the questions. In the question, they are asked to look for a combination of three numbers while students answer a combination of 4 numbers. The error can be seen in Figure 4 below.

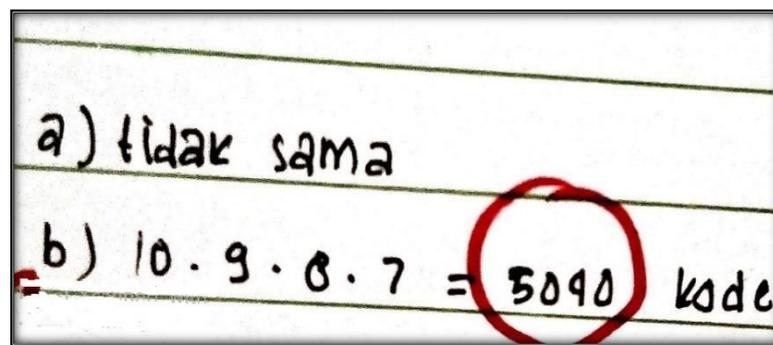


Figure 4. Example of error type reading question number 2

In the question, they were asked to find a combination of three numbers, so the right answer should be $10 \times 9 \times 8 = 720$ but one of the students, namely BP, answered $10 \times 9 \times 8 \times 7 = 5,040$.

3. Error at number 3

In question number 3, there were 13 students who made a calculation or computational error. This error occurs because students are not skilled in doing calculations. The error can be seen in Figure 5 below.



$$\begin{array}{l}
 3! \text{ Surabaya} \\
 4! \text{ Jakarta} \\
 2! \text{ Bandung}
 \end{array}
 \left. \vphantom{\begin{array}{l} 3! \\ 4! \\ 2! \end{array}} \right\}
 \begin{array}{l}
 = 3! \times 3! \times 4! \times 2! \\
 = 9 \times 9 \times 24 \times 2 \\
 = 81 \times 48 \\
 = 5184
 \end{array}$$

Figure 5. Example of error type process skills question number 3

In question number 3, students are actually correct in transforming the story problem into a mathematical form, it's just that they have an error in calculating or computation. Should. $3! = 3 \times 2 \times 1 = 6$ but here the LD student answers $3! = 9$.

4. Error at number 4

In question number 4, there were 14 students who made a calculation or computational error. This error is caused because students are not skilled in doing calculations. The error can be seen in Figure 6 below.

$$\begin{array}{l}
 3C_{21} = \frac{21!}{(21-3)! \cdot 3!} \\
 = \frac{21 \cdot 20 \cdot 19 \cdot 18!}{18! \cdot 3!} \\
 = \frac{12.980}{6} \\
 = 2163.3 \rightarrow 2163
 \end{array}$$

Figure 6. Example of error type process skills question number 4

The multiplication result of $21 \times 20 \times 19$ is 7,980, but in Figure 6 it is known that GN students write that the multiplication result of $21 \times 20 \times 19$ is 12,980. During the interview, GN said that he was not careful in calculating while showing the results of his calculations.



CONCLUSION

Based on the results of the analysis above, it was obtained from question number 1 of reading questions as many as 0 students, errors in understanding questions as many as 35 students, transformation errors as many as 0 students, process skills errors as many as 0 students, and writing errors as many as 0 students. In question number 2, 8 students misreaded the question, 0 students misunderstood the question, 0 students' transformation errors, 0 students' process skills errors, and 0 students' writing errors. In question number 3, 0 students misunderstood the questions, 0 students misunderstood the questions, 0 students' transformation errors, 13 students' process skills errors, and 1 student's writing error. In question number 4, 0 students misunderstood the question, 1 student misunderstood the question, 0 students' transformation errors, 14 students' process skills errors, and 0 students' writing errors. The most mistakes made by students in doing the questions of the fundamental enumeration method, namely errors in understanding the questions and errors in process skills. Both errors caused the writing of the final answer to be incorrect.

The factor causing students' mistakes in understanding the problem is because students still have difficulty in understanding the concept of permutation and the concept of combination. Meanwhile, the factor causing students' mistakes in process skills is because students are not used to calculating but always rely on calculators. To reduce these mistakes, an evaluation of the way lecturers teach can be carried out. Lecturers in teaching should give many examples related to differences in permutations and combinations. Lecturers increase the practice of questions so that students become more accustomed to calculating and doing questions. The provision of practice questions should also vary in level of difficulty, ranging from simple questions to difficult questions. Prohibit the use of calculators in classroom learning so that students are accustomed to calculating quickly and precisely.



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