UJMER 10 (1) 2021 32 – 40

Unnes Journal of Mathematics Education Research

http://journal.unnes.ac.id/sju/index.php/ujmer

Diagnostic Analysis of Newman's Types of Students' Error in Finishing Questions of Mathematical Problem Solving

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Article Info

Article History:
Received 15 October 2019
Accepted 21 February 2020
Published 15 June 2021

Keywords:
Newman diagnostic type of error, Mathematical Problem Solving

Abstract

This study was aimed at understanding the diagnostic description of the students' errors types according to Newman in solving the questions of mathematical problem-solving. This study was qualitative. Purposive sampling was used in this study that based on Newman's theory of five errors' types, namely reading error, comprehension error, transformation error, process skill error, and encoding error. The instruments used in this study were the test of the ability to solve mathematical problem and interview. The subject of the study was grouped based on the errors conducted by the eighth-grade students of MTs Al Ma'arif Rakit in solving the question. The result showed that the students' error was varied. The diagnostic results showed that among the 26 students who did four exercises of mathematical problem solving, 3 students did the reading error, 6 students did the comprehension error, 7 students did the transformation error, 9 students did the process skill error, and 11 students did the encoding error.

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p-ISSN 2252-6455
e-ISSN 2502-4507

INTRODUCTION

Since the world faces the globalization era, education is demanded to create competent and thoughtful human resources to take part in society. One of the ways to achieve it is by building the competence of students to have higher order thinking skill (HOTS). HOTS consist of some sub-skills. One of them is the ability to solve the problem. International Life Skills Survey (2000) stated that the ability to solve a problem is needed by someone to participate effectively in a qualitative situation that appears in life and work setting. Therefore, this ability becomes one of the important abilities needed by the student to live a competitive life in the globalization era.

The term 'ability' etymologically comes from the word 'able' which means capable to do something (Depdiknas, 2008). According to Stephen & Timothy (2009), terminologically, ability means the capacity of someone to do some tasks in a certain job. Problem-solving refers to the effort of someone to achieve the goal as they do not have an automatic solution (Schunk, 2012). Meanwhile, the ability to solve a mathematical problem is the effort of students in searching for the solution to solve the problem.

In a developed country, the problem-solving ability has become a serious thing. Even the problem to solve the low competence of solving the mathematical problem of the students becomes an obstacle for the math teachers in many countries (Daneshamooz, Alamolhodae, dan Darvishian, 2012). Thus, this problem becomes the main topic in the mathematic field till nowadays (Caballero, Blanco, dan Guerrero, 2011; Pearce, *et al*, 2013).

The survey of OECD (*Organisation for Economic Co-operation and Development*) mentioned that according to PISA 2015, Indonesia was on the top of 69 among the 79 countries (OECD, 2018). Based on that rank, compared to the other countries, the mathematical ability of Indonesian students was relatively low, including the problem-solving ability.

To master the problem-solving ability as mentioned in the general goal of mathematic learning, students need to practice to do the exercise of mathematical problem-solving. This aims at making students get enough practices in solving the mathematical problem solving, especially in daily life context. Suherman, et.al., (2003) stated that one of the ways to develop the students' ability to solve a mathematical problem is by providing the related exercise that needed many strategies to solve it. Based on that condition, the students can solve the problem using many strategies. Meanwhile, NCTM (2000) divided the indicators of problem solving ability into four, such as: (1) constructing new mathematical knowledge through problem solving, (2) problem solving appears in mathematics and other fields, (3) applying and adjusting various appropriate strategies to solve the problems, and (4) observing and developing the solving process. Therefore, the problems that will be given to the students to cover the four indicators.

For students, mathematics becomes one of the hardest subjects. It is indicated by the difficulties in solving mathematical exercises. Hafid, Kartono, & Suhito (2016) revealed the data that shows the students' difficulties in learning mathematics. It is indicated by the low score of the students. In line with the opinion of Djamarah (2011) that stated the students' difficulties in learning mathematics can be seen from these following signs: (1) showing the low achievement of learning, (2) the result that has been achieved is not balance with the effort that has been done, (3) showing a slow progress in doing the tasks, (4) showing inappropriate attitude, and (5) showing the unpopular behavior. Ruswati, Utami, & Senjayawati (2018), on their study also reported that in doing the circle exercise, the ninth grade students of SMP Negeri 47 Bandung having difficulties in solving a mathematical problem. Majority students have understood the main problem given by the teachers and they have found the concept that must be used in solving the problems. Otherwise, the students still doing mistakes especially on the steps of solving the problem and calculating process.

The teacher needs to analysis students' error eagerly in the learning process. This is due to a teacher to understand errors, explains what students face, and find the cause of student's error, until they can improve their understanding and skill (Satoto, Sutarto, & Pujiastuti, 2012; Yuniati, 2014; Zainuddin, Abidin, A., & Susanti, 2018). The teacher's observation towards students' works in solving questions can be done with using certain procedures and in the current study is using Newman

procedure (NEA). NEA is a framework with a simple diagnostic procedure (Junaedi, 2012). The error procedure according to Newman is divided into 5, namely 1) Reading errors, 2) Comprehension errors, 3) Transformation errors, 4) Process Skill error, 5) Encoding error (Hafid, Kartono, & Suhito, 2016; Suyitno, 2018).

NEA procedure according to the cause of students' errors in solving the question covers (1) Reading error; this error happens either in reading the meaning of questions or defining the meaning of symbols, terms, or words contains in the question. Islamiyah, Prayitno, & Amrullah (2018) stated that generally, students are fluent in reading the questions but they have difficulties in finding the meanings in the sentence that contains in the question. Rokhimah, Suyitno dan Sukestiyarno (2015) also stated that students can be defined as doing errors if they do not understand the meaning of the words in the questions or defining the important word in the question. (2) Comprehension errors; this errors happened when students able to understand the meaning of the question, but do not understand what is known and what is asked in the question. (3) Transformation error; this error happens when students failed to determine the formula that should be used in solving the question, failed to choose the strategy or procedure in making pictures or sketch to help in solving the question. (4) Process Skill error; this error happened when students failed to accomplish the procedure of the answer according to the algorithm. (5) Encoding error; this error happened when students failed to get the correct answer according to the question (Hafid, Kartono, & Suhito, 2016; Suyitno, 2018).

Based on the explanation above, the question related to the study is how the diagnostic description students' errors type according to Newman in solving the mathematical question. The study aims to get the diagnostic description of types of student's errors based on Newman in solving a mathematical question.

METHOD

The study used a qualitative method. The researcher revealed the phenomenon faced by the subject of the study, which covers behavior, perception, motivation, or action. Later the result was described in the form of word and language in a particular context that is natural and utilizing various scientific methods. (Moleong, 2009).

The study was done in MTs Al-Ma'arif Rakit in year 2018/2019. The subject of the study was 26 students in class VIII F. The technique of choosing the interview subject was done with purposive sampling technique. According to Sugiyono, the sampling technique is a sample taking the technique from the data source with a certain consideration (Sugiyono, 2013).

The technique of collecting data was using test and interview. The interview was focused on the errors done by the students in the test answer. Interview was divided based on the type of errors namely reading, comprehension, transformation, process skill, and decoding. To measure the validity of the data, data triangulation was used through test result and interview. Later the data were analyzed with data reduction with the students' ability to solve problem classification result based on the type of errors and later the data was presented in form of table and description and classified and concluded (Sugiyono, 2010).

RESULT AND DISCUSSION

Table 1. The result entirely presented in table 1:

Types of Error	The Percentage of Error in Every Question(%)			
	Soal 1	Soal 2	Soal 3	Soal 4
R	4,2	0	3,5	10,7
C	25	8	10,7	14,3
T	12,5	28	17,9	17,9
P	12,5	32	32,1	21,4
E	45,8	32	35,7	35,7

Based on the table above, the analysis of the diagnostic of students' errors for each type is explained above.

Result

The Diagnostic of Reading Error Type

The error happens when students unable to read the meaning of the question, whether in reading

the meaning of the question or do not have knowledge related to the meaning of symbols, terms, or word contained in the question. Students have already fluent in reading the question but they have difficulties in defining the meaning of the sentence in the question. The students' errors in this level are based on student's criteria that able to read, however, they do not understand what they read, unable to find keywords, or symbols in the question until they were unable to understand the question properly and later difficult to find the accuracy of problem-solving.

On question number 1, the keyword to solve the question was to find odd numbers from 1 to 16. Few students were confused in understanding the question until it was difficult to differentiate what is known and what is asked in the question. Besides that, few students also wrong in interpreting the question until they were difficult to complete the next step.

On question number 3, the keyword to solve the question was a red box that gets the probability to the car. In answering the question, students were less careful in understanding the question especially in identifying what is known in the question. On question number 4, the solving keyword was by pairing provided menu either for the ingredients, how to cook, and the complement. Few students were distracted in understanding the meaning of the question and later confuse in giving the solution for the question.

The Diagnostic of Comprehension Error Type

This error happens when students able to understand the meaning of the question, but do not know what is known and asked in the question. The student's error in this level is based on the students' criteria that unable to read and find the keyword, or symbols in the question until they are unable to understand the further problem and unable to find the accuracy of the solving the problem. On question number 1, it was known on the question that book's number of 1-16 and it was asked that the probability of odd number book. Few students confused in understanding what is known and what is asked, even they tended to invert in writing it until unable to solve the question accurately. On question number 2, it was known that coin flipped back for 48 times and on the coin, the number appears 12 times. Majority of the students already able to understand what is known and what is asked, however, few students were less careful in rewriting the number until it impedes them to answer the question correctly. On question number 3, majority of the students tend not to mention what is known and asked on the question. However, they understand the question well. On question number 4, majority of the students already understand what is known and asked in the question until they were able to answer the question correctly.

The Diagnostic of Transformation Error Type

This error happened when students failed to determine the formula that is used in solving the problem, fail to choose the strategy or procedure in answering the question, and fail in making picture or sketch that help to solve the problem.

On question number 1, the strategy used to solve the question was by observing the known number and counting the odd number for sample space. The formula used to solve the question was using probability theoretic formula, namely $(A) = \frac{n(A)}{n(S)}$. Few students did error at the placement of sample point and sample place to the formula until they were unable to get the correct answer. On question number 2, the strategy used to solve the question was by identifying what is known and applying it to the probability empiric formula. The formula used to solve the question was the empirical probability formula, namely $P(B) = 1 - P(A)$ with $P(A) = \frac{\text{frecuency of event occur}}{\text{frequency of trial}}$. Majority of the students were distracted with the question namely determining the probability of the head of coin to appear and not the number. And few students failed to determine the correct formula.

On question number 3, the strategy used to solve the question was by identifying the known value and then comparing it. The formula used to solve the question was by theoretical probability formula namely $(A) = \frac{n(A)}{n(S)}$. In answering it, the students were less careful to understand the question especially in identifying what is known in question. On question number 4, the strategy used to solve the question is by pairing every provided menu. The way that can be used to solve the question is by table or factor tree. Several students have difficulties in

determining the way to solve the question and other students unable to solve the question until they cannot answer the question correctly.

The Diagnostic of Process Skill Error Type

The error happened when students failed to perform the procedure of the answer according to the algorithm in solving the problem. On question number 1, few students that doing error on process skill did not give assumption towards the answer. For example in answering question number 1, students supposed to make assumption A as the odd number of the book, so the odd number was notated as $n(A) = 8$. The students tended to answer $A = \{1,3, \dots, \dots\}$. (writing the written odd number). Few students also did errors on sets without joining brackets in identifying the odd number sets and sample space. Meanwhile, in the calculation phase on question number 1, the students did not do any errors.

On question number 2, errors done by students on process skill was the fraction simplification process. Students who answered correctly the empiric probability for question number 2, namely $\frac{36}{48}$ was confused in the simplification process into $\frac{4}{3}$ and not $\frac{3}{4}$. Other than that, the error of the assumption and the writing of sets for example in question number 1 also done by few students in answering question number 2. Based on this error, few students failed to answer the question correctly.

On question number 3, error done by students on process skill was similar with number 1 and 2, namely on the assumption. Other than that, students also confuse in determining the sample space. As in box number 1, students suppose, to sum up, the box $A = 8 + 9 + 10 = 27$, but they confuse and searching for the sample space by summing up the probability of red box that represents the car, namely $8 + 10 + 12 = 30$.

On question number 4, error done by students on process skill was on the process of pairing the menu by factor tree. Few students did not pair every ingredients, way to cook, and the complement entirely or few menus did not pair with other menus.

The Diagnostic of Encoding Error Type

The error happens when students fail to get the correct answer based on the question asked. Majority of students' error in this level is not rechecking the answer and do not give a conclusion at the end of the answer. Few other errors done by students are when they give a wrong conclusion that inappropriate with the answer in the problem-solving process. On question number 1, a conclusion that supposes to be answered by students was the probability of the odd number of the book that took $P(A) = \frac{1}{2}$. However, because few students have done error in the previous step, so at the step of checking the result, the students did not get the correct answer. Few other students did error on the conclusion as they did not check the question. On question number 2, the conclusion that should be given was the empirical probability that appears the head of the coin and not the number is $\frac{3}{4}$. However, few students did not give a correct answer, because they did error on the previous step, especially on process skill level.

On question number 3, the conclusion need to be given was the box that has the biggest probability to get the car is box A. Majority of the students did error on process skill level, on the last step students' answer was box C, until they did not get the correct answer. On question number 4, the conclusion needs to be given was, the amount of menu list that can be made in the restaurant "uenaak" was 24. Majority of the students did not do the process skill or did not find the amount of menu that could be made until the answer given by the students was incomplete and the majority of the students did not give conclusion in this level.

Based on the diagnostic result the ability to solve the problem based on each type, the error made by the students in solving the problem is encoding type.

Discussion

A qualitative study was done to know the description of the ability to solve the mathematical problem based on the type of error. Based on the result of the description, it is known that the amount of error done by the students in solving the problem is on encoding type. This is in line with the research done by Haryati, Suyitno & Junaedi (2016),

Islamiyah, Prayitno, & Amrullah (2018), and Safitri, Sugiarti, & Hutama (2019). This proved that the higher the category of the type of error, therefore the chance of error made by the students becomes higher too.

The student's ability to solve the problem of the reading type of error, comprehension error type, transformation error type, process skill error type, an encoding error type are different. Students with reading type unable to reach the stage of problem-solving on the indicator of constructing the new knowledge of mathematics through problem-solving. Students with comprehension type able to reach the level of arranging the solving problem plan and doing the problem-solving planning on the indicator of problem-solving that appear in mathematics and other domain. Students with transformation type able to do the problem understanding stage and arranging the solving problem planning on the indicator of applying and adjusting various kinds of strategies that suitable for problem-solving. Students with process skill able to do the level of understanding problem and arranging problem-solving planning on the indicator of observing and developing the solving process. Meanwhile students with encoding type able to do the stage of the understanding problem, arranging the problem-solving planning, and doing the problem-solving planning on the indicator of constructing new mathematics knowledge through problem-solving.

The subject with reading type error in this stage is difficult to understand problems, doing the problem-solving planning, and rechecking the result of problem-solving. This is in line with the interview result got from the students with this type that need a long time in knowing the reading in the question and need to read the question for few times until they can understand the question well. Even though they can mention the solving problem plan correctly, however students of this type cannot complete the plan as it revealed in the interview result that students cannot solve the question. Because of the error from the previous step, reading type also did error on the next step, including the rechecking step. This is in line with the opinion of Oktaviana (2017) that stated the students' ability in reading will influence their way of solving the problem.

It also the same with Comprehension type, even though the students able to do the arranging plan step and question-solving, but as they do errors on understanding problem step and rechecking, it can be said that they were unable to get the right answer. This is similar with Pratiwi (2015) that students are said can reach the understanding level when they can explain the problem in the question and they seem difficult to articulate the reason in understanding a particular reading.

It is similar to the students with transformation and process skill type of error, where the students able to understand the problem and the problem-solving plan, but as they did error on transformation and process skill, they able to understand the problem and plan, and did not able to solve the question correctly. Students that do the encoding error type are already able to understand the problem, arrange the problem-solving plan, do the problem-solving plan, but unable to get the correct answer. This is in line with Junaedi (2012) and Haryati, Suyitno, & Junaedi (2016) who stated that in NEA, the error from the previous step influence the next answer until if the result of students' answer shows that students did error in reading step, therefore the analysis cannot be continued to the next four steps. This is supported by Ellerton & Clements (1996) that revealed the NEA framework is a hierarchy as the error in each step of solving process could impede students to get the right answer.

Based on the analysis of the ability to solve the problem above, it is known that every subject different category of error has a different ability of problem-solving. Subject with reading error type is less capable to solve the problem because they only able to do the problem-solving plan. The subjects with comprehension error type are less capable in solving a problem as they were only able to do the indicator of a problem-solving plan and do the problem-solving plan. Subjects with the transformation and process skill error can understand the problem and plan, but unable to solve the problem as they only do the understanding problem indicator and problem-solving plan. Meanwhile encoding error type able to solve the problem well as they were able to do the understanding problem

indicator and problem-solving plan, and do the problem-solving plan well.

CONCLUSION

Based on the analysis result and findings, it is concluded that the description of students' diagnostic error type according to Newman in solving the mathematical problem shows various result. It shows that students' error on every question is different and fluctuating if they were trained continuously.

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