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Using Newman Error Analysis to Detect Students' Error in Solving Junior High School Mathematics Problem

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Abstract: The existence of student errors is due to the inability of the students to receive and process the information contained in the given questions. Therefore, it is necessary to conduct an analysis to find out student errors so that the results obtained in the analysis can be used by teachers to provide appropriate assistance to students, either through methods or media in learning mathematics. This study is a qualitative descriptive study. The purpose of this study was to find out how many errors were made by the eighth-grade class of Nurul Falah MTs in solving math problems according to Newman's theory in school year 2021/2022. So that solutions to reduce errors can be found and also to emphasize which parts require a deeper understanding in solving math problems. The results of the analysis showed that the percentage of student errors in the Reading Error (RE) phase was 13.33%, Reading Comprehension (RC) phase was 42.22%, Transformation Error (TE) phase was 28.89%, Process Skill (PS) phase was 71.11%, and the Encoding Error (EE) phase was 86.67%. From the results of the analysis, it can be seen that the most errors made by students are Encoding Error, which are 86.67%.

Keywords: student error analysis, Islamic junior high school, Newman's Theory.

Abstrak: *Adanya kesalahan para siswa dikarenakan belum mampunya menerima dan mengolah informasi yang ada pada soal yang diberikan. Oleh karena itu perlu dilakukan analisis dalam mengetahui kesalahan-kesalahan siswa sehingga dengan hasil yang diperoleh dalam analisis dapat digunakan oleh guru untuk memberikan bantuan yang tepat, baik melalui metode ataupun media dalam pembelajaran, kepada para siswa. Penelitian ini adalah penelitian deskriptif kualitatif. Adapun tujuan dari penelitian ini adalah mengetahui seberapa besar tingkat kesalahan yang dilakukan oleh para siswa kelas VIII MTs Nurul Falah Kefamenanu dalam menyelesaikan soal matematika menurut teori Newman pada tahun ajaran 2021/2022. Sehingga solusi untuk mengurangi kesalahan dapat ditemukan dan juga untuk menekankan dibagian mana saja yang membutuhkan pemahaman yang lebih mendalam dalam menyelesaikan soal matematika. Hasil analisis yang dilakukan menunjukkan bahwa) persentase kesalahan siswa pada tahapan Reading Error (RE) sebesar 13.33%, tahapan Reading Comprehension (RC) sebesar 42.22%, tahapan Transform Error (TE) sebesar 28.89%, tahapan Process Skill (PS) sebesar 71.11%, dan tahapan Encoding Error (EE) sebesar 86.67%. Dari hasil analisis tersebut terlihat bahwa kesalahan yang paling banyak dilakukan oleh para siswa adalah kesalahan Encoding Error atau kesalahan dalam pengkodean, yaitu sebesar 86.67%.*

Kata kunci: *analisis kesalahan siswa, MTs, Teori Newman.*

▪ INTRODUCTION

Mathematics is a subject that is taught at every level of education in Indonesia, such as Elementary School, Junior High School, Senior High/Vocational School, and universities. In the process of learning mathematics, students are trained to think critically and logically (Syuhada et al., 2017). Therefore, it is not rare to find students learning mathematics who have very poor understanding. This can be caused by the lack of

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student's abilities in obtaining, managing, and utilizing information to solve math problems (Lubis et al., 2021). These obstacles cause students to make mistakes in solving problems.

Timor Tengah Utara (TTU) District is one of the areas in the province East Nusa Tenggara (NTT) which is directly adjacent to the Timor Leste country, which is bordered in the north by Ambenu sub-district. Data obtained from the Education Assessment Center of the Ministry of Education and Culture (Kemdikbud 2020) shows that, in 2017 the number of students who answered correctly the Mathematics National Examination (UN) was at the highest percentage. It was 52,76 %, in other words as many as 47,24 % of North Central Timor (TTU) Junior High School students answered math questions in national examination incorrectly. Meanwhile, in 2018, it was the year in which junior high school students at TTU made the most errors in answering Mathematics national examination questions, which was 57.24%. For more complete information see table 1.

Table 1. The average of junior high school students who answered math questions in national examination correctly

Year	TTU District	NTT Province
2015	47.24%	50.65%
2016	42.47%	42.02%
2017	52.76%	48.93%
2018	42.26%	43%
2019	45.54%	47.36%

Based on table 1, the percentage of TTU District Junior High School students who makes errors in answering mathematics national examination questions was not in small numbers, this is also supported by the interview conducted by researchers with mathematics teacher for eight-grade class MTs Nurul Falah Kefamenanu TTU District, that most of the students made errors in solving math problems. The students' errors were due to their inability to receive and process the information contained in the given questions. Therefore, it is necessary to conduct an analysis to find out student errors so that the results obtained in the analysis can be used by teachers to provide appropriate assistance, either through methods or media in learning, to students.

The theory of error analysis used in this study is Newman's theory. Newman stated that the phases taken to analyze the errors made by students in solving word problems were reading, comprehension, transformation, process skill, and encoding. Newman stated that errors in reading the questions can occur because students have errors in reading the main information in the questions. Errors in comprehend the problems occur because students do not understand the concepts used in the questions and ultimately cause the information provided in the questions not to be well received by students. Transformation errors occur because students have not been able to change the given question into a mathematical model. Process skills errors occur because students are wrong in doing computations. Errors in encoding the final answers occur because the students wrote the wrong answer to the question (Oktaviana, 2017).

Several previous studies related to the analysis of students errors in solving math problems are: error analysis on set problems (Aulia & Kartini, 2021), error analysis based on Watson's criteria (Mafruhah & Muchyidin, 2020), error analysis of algebraic fractions problems (Nurianti et al., 2015), Newman's error analysis in solving derivative of algebraic function problem (Fitriani et al., 2018), analysis of students error in solving quadratic equations using Newman's procedure (Thomas & Mahmud, 2021), analysis of

students errors in solving HOTS problems for the topic of fraction (Abdullah et al., 2015), analyzing students error in problem solving of two-variable linear equation (Santoso, 2019), analysis of GCSE resit student's errors (Tiflis et al., 2019), Newman's error analysis on evaluating and creating thinking skills for coordinates topic (Syuhada et al., 2017), Newman error analysis for errors in mathematical word questions in Sekolah Kebangsaan Taman Kluang Barat Malaysia (Seng, 2020), high school students error in solving word problem of trigonometry (Wardhani & Argaswari, 2022), error analysis of primary six pupils in word problems (Beji et al., 2018), error analysis of Newman to solve geometry problem (Zamzam & Patricia, 2018), and a study literacy about Newman's Error Analysis (NEA) review from habits of mind (Lubis et al., 2021).

There are some previous studies about NEA for pre-service teacher and professional teacher : an analysis of errors for pre-service teacher in first order ordinary differential equations (Makamure & Jojo, 2022), error analysis of pre-service teacher in Mathematical literacy (Khalo et al., 2015), and analysis students mistakes of teacher professional education based on NEA (Susanti & Taufik, 2019). Meanwhile NEA previous studies for college have been carried out by Angco (2021), Shida et al. (2019), and Abu Mansor et al. (2021). Based on the previous explanations, the researchers tried to analyze the errors made by the eight-grade students of MTs Nurul Falah Kefamenanu in solving math problems. It is expected that the results obtained by researchers in this study can assist teachers in providing appropriate assistance to the students in reducing their errors.

▪ METHOD

Participants

This study involved 15 students of eight-grade class of MTs Nurul Falah Kefamenanu as research samples from 40 students of eight-grade class research population. The subject was taken from one class of eight-grade students based on consideration of the math teacher.

Research Design and Procedures

This study was conducted in February-May 2022 at MTs Nurul Falah Kefamenanu and it is qualitative descriptive research. Qualitative descriptive research is a research whose its series of activities aim to obtain data as it is without being under certain conditions and the results of this research emphasize more on meaning (Sugiyono, 2015). Also, this study aims to analyze and describe the types of student errors in solving mathematical word problems about polyhedron based on the phases of Newman's procedure.

The steps in this study were: first of all, determine the background of the problem and formulate the problem. Based on the interview conducted by researchers with mathematics teacher of MTs Nurul Falah Kefamenanu, most of the students' made errors in solving math problems whether it's seventh-grade, eight-grade, or ninth-grade students. The students' errors were due to their inability to receive and process the information contained in the given questions. After formulating the problem, then look for supporting theories that support the research. And then, the researcher determined the population and the research sample. The researcher made an instrument in the form of mathematical word problems about polyhedrons. The questions are selected and used as a test. After that the test is given to the specified sample, then the data will be presented

in tabular form and the data will be analyzed to see the phenomena that occur. After the researcher gave the test, the researcher corrected the students answers and gave a score.

Instrument

The instrument used in this study was description in the form of mathematical word problem. The questions given to the students were 3 math word problem about polyhedrons. The instrument is used to diagnose errors made by students for later researchers used in finding relevant data from students (Nurdiawan & Zanthy, 2019). Then the instrument was tested for validity and reliability, as below:

Table 2. Correlation Test

Correlations

		1	2	3	TOTAL
Problem1	Pearson Correlation	1	.247	.344	.569*
	Sig. (2-tailed)		.375	.209	.027
	N	15	15	15	15
Problem2	Pearson Correlation	.247	1	.835**	.897**
	Sig. (2-tailed)	.375		<.001	<.001
	N	15	15	15	15
Problem3	Pearson Correlation	.344	.835**	1	.931**
	Sig. (2-tailed)	.209	<.001		<.001
	N	15	15	15	15
Total	Pearson Correlation	.569*	.897**	.931**	1
	Sig. (2-tailed)	.027	<.001	<.001	
	N	15	15	15	15

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Because all correlations are significant, the instrument is valid. While the result of the reliability test of the instrument that have been used are as follow:

Table 3. Reliability Test

Cronbach's Alpha	N of Items
.751	3

According to Tavakol & Dennick (2011) an instrument is said to be reliable if Cronbach's Alpha > 0.6. Therefore, it can be concluded that the instrument that has been given to students is also reliable.

Data Analysis

This study used descriptive statistical qualitative data analysis. Descriptive statistics is used to analyze data by describing the data that has been collected properly without intending to draw general conclusions (Sugiyono, 2015). In descriptive statistics, data can be presented in the tables, graphs, pie charts, and others. Descriptive statistics can also look for relationships between one another or make comparisons.

The instrument used in this research is in the form of mathematical word problems (essay questions) about polyhedrons, namely cube, cuboids, pyramid, and prism. Students are given three number of word problems which are completed during lesson hours.

Students answer questions in the form descriptions. Oktaviana (2017) stated that the NEA indicators used to analyze student errors were:

Table 4. NEA's Indicators

Type of error	Indicators
Reading Error (RE)	Student makes errors in the reading terms, symbols, words or important information in the given questions.
Reading Comprehension (RC)	1. Student does not know what is being asked in the questions. 2. Student makes errors in capturing information about questions so that they have difficulty going to the next level.
Transformation Error (TE)	1. Student makes errors in changing the problem into the correct form of a mathematical model. 2. Student makes errors in using arithmetic operations to solve problems.
Process Skill (PS)	1. Student makes errors in counting. 2. Student does not continue the solving procedure of the problem.
Encoding Error (EE)	1. Student does not get the correct answer. 2. Student cannot makes conclusions from the appropriate answers with math sentences. 3. Student makes errors because they are careless.

▪ RESULT AND DISCUSSION

Before presenting the results and discussion, the following is a mathematical word problem about polyhedron that is given to students in Bahasa and in English.

In Bahasa:

1. *Sebuah prisma alasnya berbentuk persegi panjang dengan luas alas 40 cm^2. Jika lebar persegi panjang adalah 5 cm dan tinggi prismanya adalah 12 cm, hitunglah luas permukaan prisma.*
2. *Sebuah limas mempunyai alas berbentuk persegi. Keliling alas limas 96 cm, sedangkan tingginya 16 cm. Hitunglah luas seluruh permukaan limas tersebut.*
3. *Volume sebuah prisma adalah 540 dm^3. Jika alas prisma berbentuk segitiga dengan panjang rusuk masing-masing 5 dm, 12 dm, dan 13 dm, maka tentukan luas permukaan prisma tersebut.*

In English:

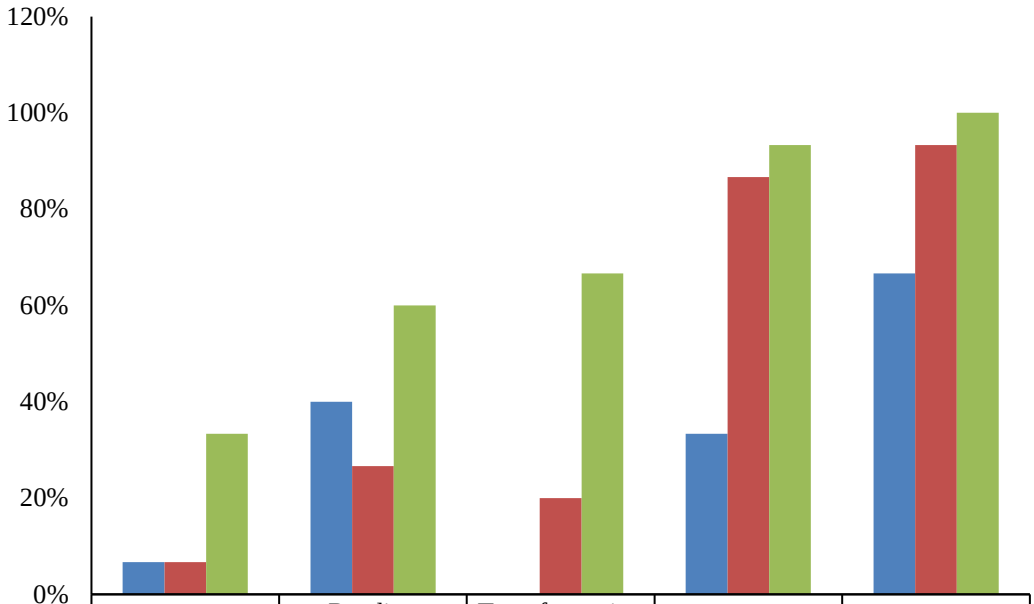
1. A prism has a rectangular base with the area of base is 40 cm^2. If the width of the rectangle is 5 cm and the height of the prism is 12 cm, calculate the area of surface of the prism.
2. A pyramid has a square base. The circumference of the base of the pyramid is 96 cm, while the height is 16 cm. Calculate the total surface area of the pyramid.
3. The volume of the prism is 540 dm^3. If the base of the prism is triangular with side lengths of 5 dm, 12 dm, and 13 dm, respectively, determine the area of surface of the prism.

The following is the explanation of the types of errors from 15 students of eight-grade class of MTs Nurul Falah Kefamenanu:

Table 5. Types of Errors of Each Students

No.	Student Initial	Question Number	Types of Errors				
			RE	RC	TE	PC	EE
1.	AMAN	1	√	-	-	-	√
		2	-	-	√	√	√
		3	-	√	√	√	√
2.	TAR	1	-	-	-	√	-
		2	-	-	-	√	√
		3	-	-	-	√	√
3.	A	1	-	-	-	√	√
		2	-	-	-	√	√
		3	-	-	-	√	√
4.	AW	1	-	-	-	√	-
		2	-	√	-	√	√
		3	-	√	√	√	√
5.	MFSA	1	-	-	-	-	√
		2	-	-	-	√	√
		3	√	√	√	√	√
6.	MAJ	1	-	√	-	-	√
		2	-	-	-	√	√
		3	-	-	√	√	√
7.	FN	1	-	-	-	-	√
		2	-	-	-	√	√
		3	√	√	√	√	√
8.	FR	1	-	√	-	√	√
		2	-	-	-	√	√
		3	-	√	√	√	√
9.	AAN	1	-	√	-	√	-
		2	√	√	√	√	√
		3	√	√	√	√	√
10.	MNA	1	-	√	-	-	√
		2	-	-	-	√	√
		3	√	√	√	√	√
11.	FFS	1	-	√	-	-	√
		2	-	√	√	√	√
		3	√	√	√	√	√
12.	AMA	1	-	-	-	-	√
		2	-	-	-	-	√
		3	-	-	-	√	√
13.	FTA	1	-	√	-	-	-
		2	-	-	-	√	√
		3	-	√	√	√	√
14.	NA	1	-	-	-	-	√
		2	-	√	-	√	√
		3	-	-	-	√	√
15.	SDN	1	-	-	-	-	-
		2	-	-	-	-	-
		3	-	-	-	-	√

Based on the table above, it can be concluded that the percentages of student errors are:



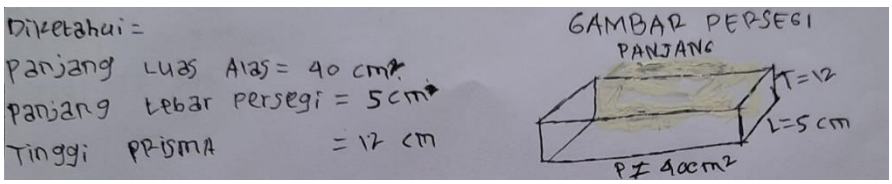
	Reading Error	Reading Comprehension	Transformation Error	Process Skill	Encoding Error
Question No. 1	6.67%	40%	0%	33.33%	66.67%
Question No. 2	6.67%	26.67%	20%	86.67%	93.33%
Question No. 3	33.33%	60%	66.67%	93.33%	100%

Figure 1. Percentages of Student Errors for Each Question

It is obtained from figure 1 that the most error made from 15 students is in encoding error. It means, most students do not get the correct answer of each question, cannot make conclusions from the appropriate answers with math sentences, or most of them make errors because they are careless. It also can be inferred that if the students make error in process skills, then tendency to make error in encoding can also occur. This is based on the percentage of student errors at the phase of process skill and encoding error are not much different when compared to other phases, it is about 15.56 %. Based on the previous explanation, the following is an analysis of the types of errors of eight-grade students of MTs Nurul Falah Kefamenanu:

1. Reading Error

There is an average of 6.67 % students who have error in reading for this research. Here reading is reading the questions and then students are asked to write in symbols or mathematical models about the information obtained from the questions.



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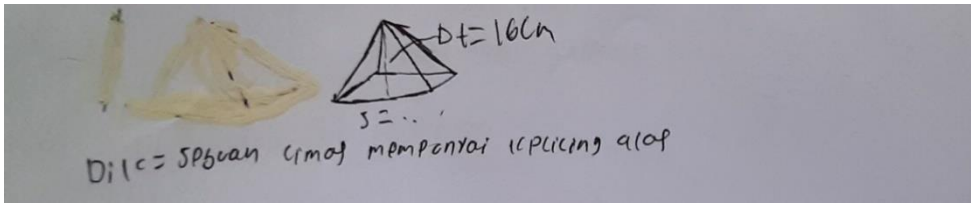

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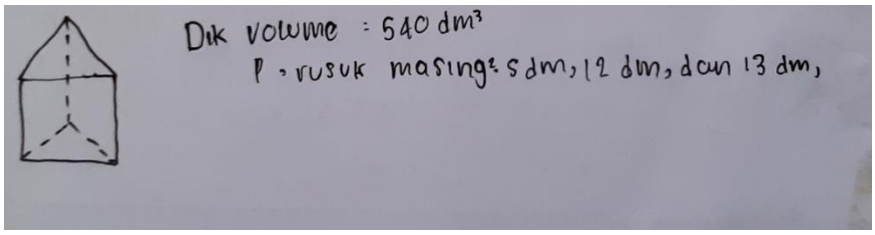


(c)

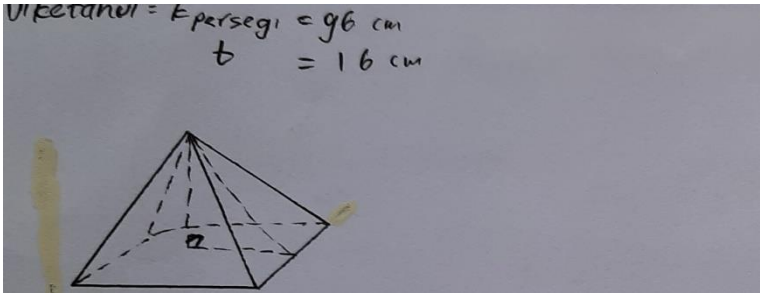
Figure 2. Examples of Reading Error (a) Question No. 1, (b) No. 2, (c) No. 3

Figure 2 above are examples of reading error. Students who have reading error are mostly caused by students' inability to write the correct symbols about the information that is known. For instance, in figure 2(a), what should be known for question number 1 is the area of base or in Bahasa "*luas alas*", but the student wrote the length of the area of base or "*panjang luas alas*" in Bahasa. In figure 2(b), student only wrote the circumference of base of pyramid or in Bahasa the student wrote "*sebuah limas mempunyai keliling alas*" while what is known from question number 2 is the circumference of base of the pyramid is 96 cm. Figure 2(c) shows reading error because student only wrote the length of each side without writing which side is 5 cm, 12 cm, and 13 cm while the information obtained from question number 3 are the volume of the prism and the length of the triangular prism base. Because there is an error in reading, as results students not being able to go to the next process and will have difficulty in solving problem. This is in line with research from Seng (2020) which stated that students failed to answer the questions correctly because their poor reading skills.

2. Reading Comprehension

The third biggest error in this research was error in reading comprehension, that is equal to 42.22 % average of all students. Error in reading comprehension can be interpreted as an error in understanding the question and then writing down what was asked (Beji et al., 2018).

(a)



(b)

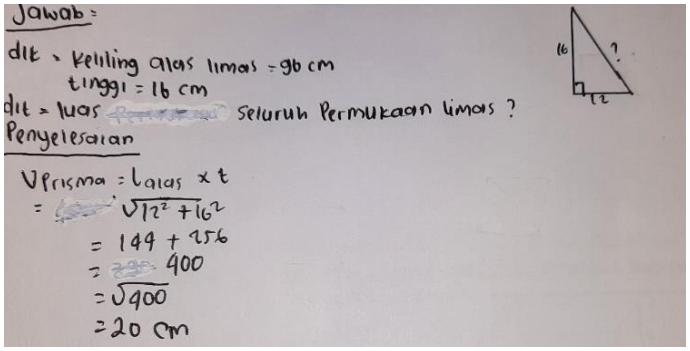
(c)

Figure 3. Error in Reading Comprehension for Question (a) No. 1, (b) No. 2, (c) No. 3

Errors in reading comprehension occur because students lack in understanding and comprehending sentences from the questions, just like shown in figure 3 above. What is being asked in question number 1 is the area of surface of the prism. While in figure 3(a) student wrote "p" or length as the question asked. In question number 2 what is being asked is the total area of surface of the pyramid, but it can be seen from figure 3(b) the student only wrote down what information he/she knows from the question and did not write what is being asked. In figure 3(c), it can be seen that student really does not know the question, which results in student not being able to write down information and what is being asked from question number 3. Of course, this comprehension reading error is also one of the biggest error that causes students difficulties in finding solutions to the questions. This is supported by the result of research from Syuhada et al. (2017), that the reading comprehension phase is one of the phases that gives biggest contribution as an error that causes students to fail justify and describe the correct final answer.

3. Transformation Error

On average, 28.89 % of students made errors in changing the problem into the correct form of a mathematical model or in using arithmetic operations to solve problems of this research.



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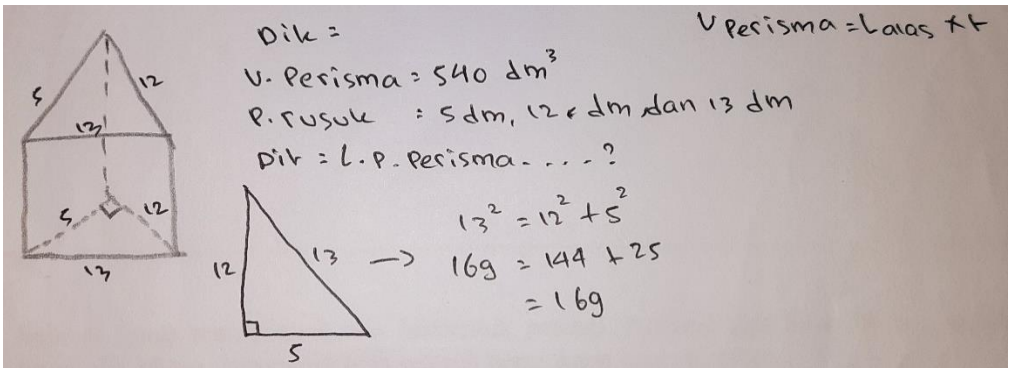


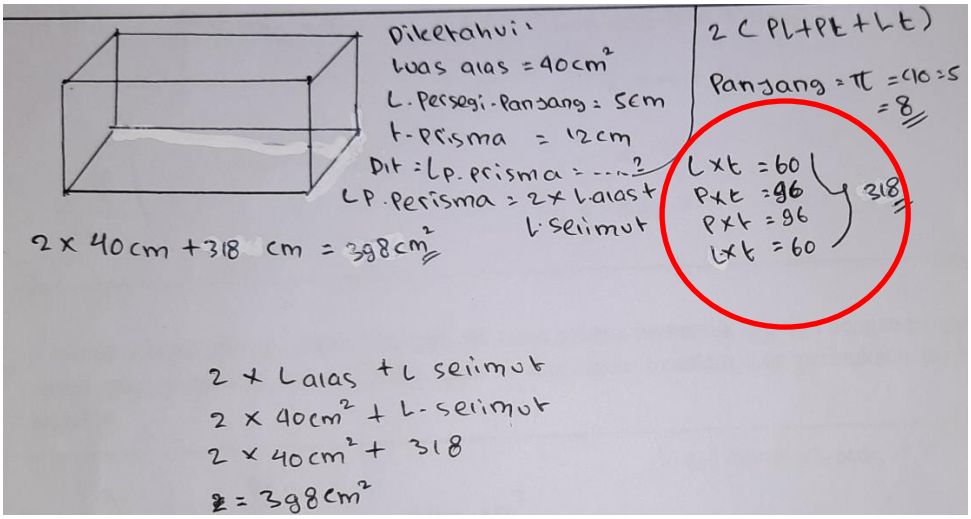
(b)

Figure 4. Example of Transformation Error for Question (a) No. 2, (b) No. 3

What is shown in figure 4(a) is the student not able to change the problem into the correct form of a mathematical model. The student only wrote down the formula for the volume of the prism whose information was not included in the question at all. While in figure 4(b), student did not write down the correct mathematical model. When student should write that the correct mathematical model is $L_p = 2 \times L_a + L_s$, If the area of surface, the area of base, and the area of side of the prism are denoted, respectively, L_p, L_a, and L_s. Transformation error can arise because students do not have the ability to distinguish between what information that is relevant and irrelevant for the questions (Tiflis et al., 2019). And this type of error causes students failed to find the right mathematical model to get the right answer. As shown in the research of Santoso (2019) which stated that the transformation error in solving mathematical word problem can cause students fail to work on questions carefully, fail to go to the next problem solving procedure, and as a result students write the wrong answers.

4. Process Skill

The average error at the process skill phase is 71.11 %, it is the second largest error in this study. Error in process skill is error caused by students failing to do the correct calculations or students cannot continue the problem solving procedure (Susanti & Taufik, 2019).



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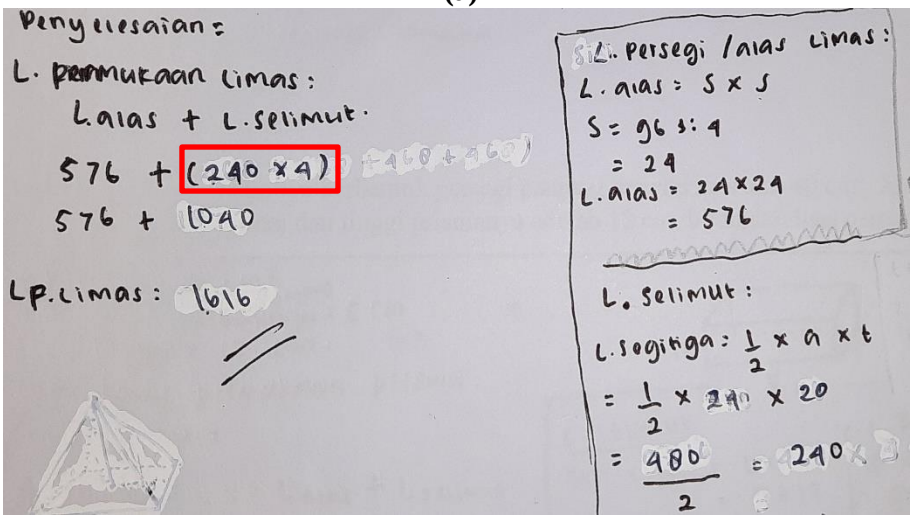

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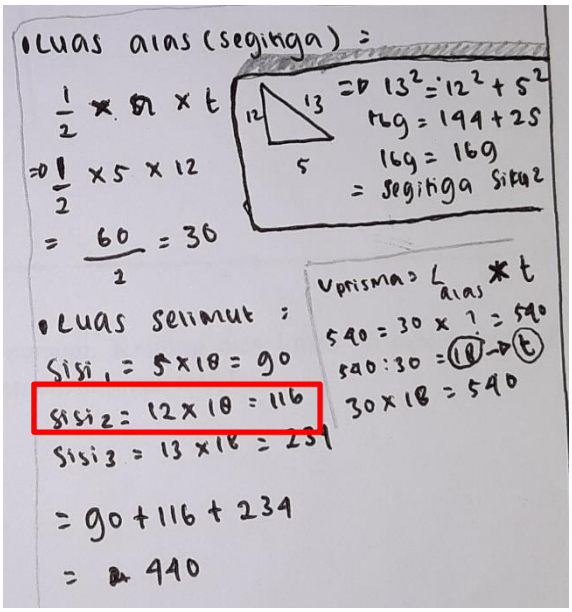


(c)

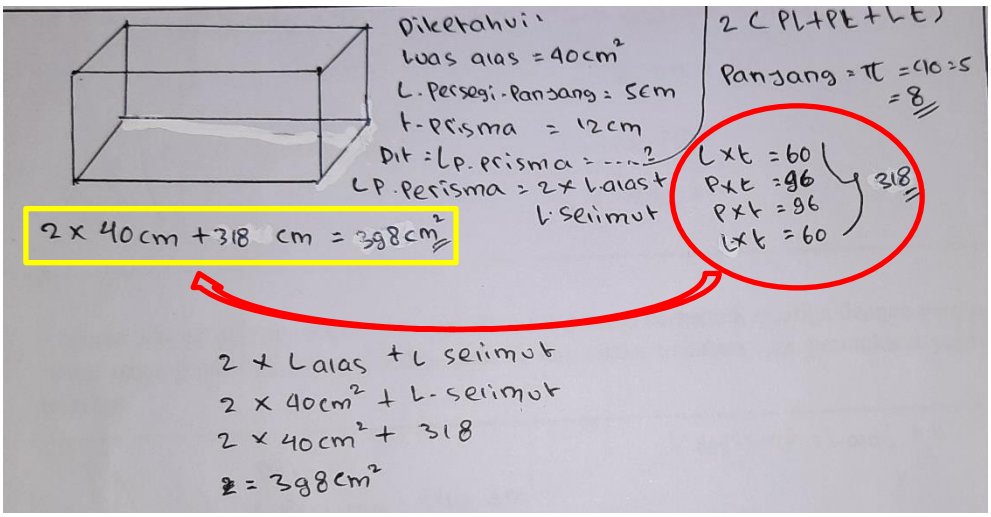
Figure 5. Example of Error in Process Skill for Question (a) No. 1, (b) No. 2, (c) No. 3

Pay attention to the step circled in red in figure 5(a), it can be seen that the student made wrong calculation. The correct calculation is 60 + 96 + 96 + 60 = 312 instead of 318. In figure 5(b) above, it can be seen that student failed to do the correct calculations (see the red one). The correct calculation is 240 × 4 = 960 not 1040. The error in process skill in figure 5(c) is the student made a mistake in writing down the product of 12 × 18 (see the red one). This error will make student wrong in calculating the total area of the upright side of the prism.

This error will obviously give the final answer which is also wrong later and this error is the result of previous errors that made by students. Such as error in transforming problem into correct formula and mathematical model. This is in line with research of Satriani et al. (2020) who argue that error in processing skill is a result of transformation errors that students did before, such as writing the wrong formula.

5. Encoding Error

The last phase to analyze student errors based on Newman's theory is encoding error. At this phase there are 86.67 % on average students who make errors.



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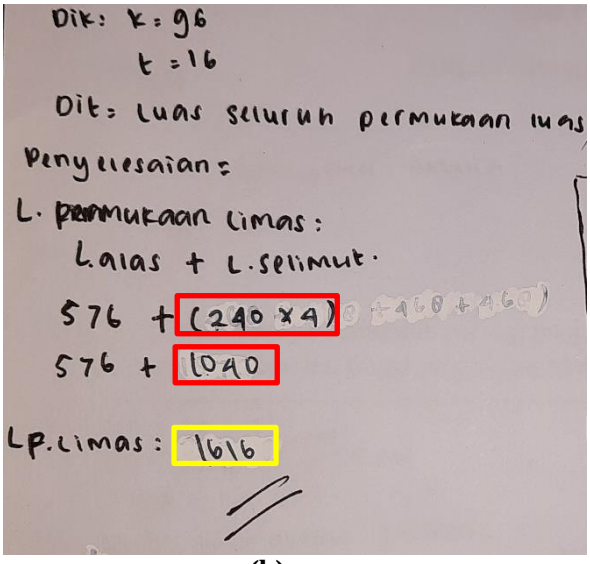

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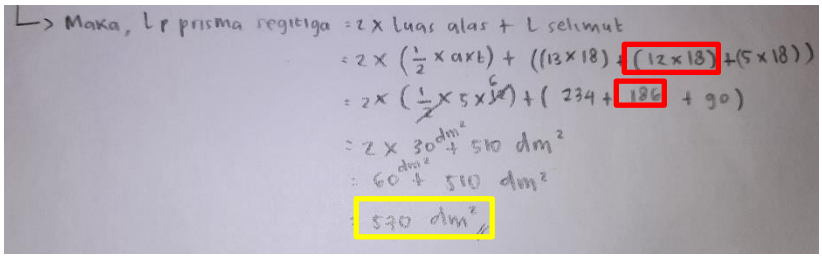

(c)

Figure 6. Example of Encoding Error

From figure 6(a), (b), and (c) it is found that errors made at the process skill phase result in encoding error. Mansor et al. (2021) also stated the same thing that the fourth phase, that is process skill. They stated that most students who make error in process skills tend to make error in incoding, that is the students record their result inappropriately.

▪ CONCLUSION

Error analysis using Newman's theory is one of the methods that can be used to find out the errors made by students in solving mathematical word problems. NEA can be done through the following phases: reading error, reading comprehension error, transformation error, process skill error, and then encoding error. In this study, it was found that the average level or percentage of students who made mistakes for each phase were : reading error 15.56 %, reading comprehension error 42.22 %, transformation error 28.89 %, process skill error 71.11 %, and encoding error 86.67 %. Basically, the phases in NEA's procedure are related to each other. In other words, some of the previous phases can affect the next phase. As in this study, errors in reading the questions resulted in errors in reading comprehension. Likewise, if students make errors in transforming questions into mathematical models, it is likely that students will also make errors in process skills and in writing the correct final answer.

With the results obtained in this research, it is hoped that it can provide an overview for teachers to determine the methods or media that can be used to assist students in reducing their errors in solving mathematical word problems. This does not mean that the methods or media used so far are wrong, but to get better results from the students, these suggestions can be made.

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