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Newman's Error Analysis on Students' Solving Numerical Problems Ability

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Abstract

It is necessary to have a suitable method in revealing students' ability to understand the concept of numbers, because it is the basis for understanding other mathematical concepts. Several errors in understanding the concept of numbers have been proven to produce mathematical learning difficulties for students. Newman's Errors Analysis (NEA) is one of the effective methods in revealing how the students' achievement in understanding the concept of numbers. Therefore, this research was conducted to see mathematical abilities when students solve numerical problems based on Newman's Errors Analysis (NEA). This research method is descriptive qualitative research having a number of research subject of five grade VII SMP students. The results obtained from this research the most students had errors on comprehension, meanwhile reading was not as fatal error. There were not big mistakes and only small errors on transformation, process skills, and encoding, Comprehension errors occurred as the result of the students' ability in reasoning was not good enough. Therefore, they failed to relate the concept of numbers to other mathematical concepts. In general, students' mathematical ability in the concept of numbers was quite good because the errors occur are were still in the low category. However, some basic errors were still exists resulting new problems in learning process. Mathematics learning improvement could be done through several things, one of them is through the analysis of students' learning difficulties on the number's concepts.

Keywords: Newman's Errors Analysis; Numerical Problems; Students' Mathematical Ability

Abstrak

Perlu adanya metode dalam mengungkap kemampuan siswa dalam memahami konsep bilangan, karena konsep bilangan merupakan basis dalam memahami konsep matematika lainnya. Beberapa kesalahan dalam memahami konsep bilangan terbukti menghasilkan adanya kesulitan belajar matematis bagi siswa. *Newman's Errors Analysis* (NEA) adalah salah satu metoda yang efektif dalam mengungkap bagaimana ketercapaian siswa dalam memahami konsep bilangan sehingga pada penelitian ini dilakukan untuk melihat kemampuan matematika berdasarkan

Newman's Errors Analysis (NEA) pada saat siswa menyelesaikan masalah-masalah bilangan. Metode penelitian ini menggunakan pendekatan deskriptif kualitatif dengan subjek penelitian sebanyak 5 siswa kelas VII SMP. Hasil yang diperoleh dari penelitian ini adalah siswa mengalami kesalahan terbesar pada *comprehension*, sedangkan *reading errors* tidak menjadi kesalahan yang fatal bagi siswa. Pada *transformation*, *process skills*, dan *encoding* tidak terjadi kesalahan yang besar meskipun masih terdapat kesalahan. Kesalahan *comprehension* terjadi akibat kemampuan siswa dalam bernalar yang masih belum begitu baik, sehingga gagal dalam mengaitkan konsep bilangan dengan konsep matematika lainnya. Secara umum, kemampuan matematika siswa dalam konsep bilangan sudah cukup baik karena kesalahan yang terjadi masih pada kategori kecil. Namun, masih terjadi beberapa kesalahan yang dasar sehingga akan mengakibatkan adanya masalah baru dalam pembelajaran. Perbaikan pembelajaran matematika dapat dilakukan melalui beberapa hal yang salah satunya adalah melalui analisis kesulitan belajar siswa pada konsep bilangan.

Kata Kunci: Analisis Kesalahan Newman; Kemampuan Matematika Siswa; Soal Bilangan

Introduction

Education is one of efforts to improve the quality of human resources. The implementation has to be managed properly. Education is also all parties' responsibility, not only government and community but also all parents. If all elements are involved and they collaborate each other, then the goal of national education to educate people's life will be achieved properly (Finandar, 2017). Mathematics is a universal knowledge underlying modern technology development having an important role in developing human thinking ability, as well as a means of scientific communication about patterns to train logical, critical, creative, and innovative thinking. Waller and Flood (2016) explained that mathematics is a verbal language and symbols. Adoniou and Qing (2014) argued that mathematics is a universal language that can be understood by all groups with various languages used.

In addition, Al-Agili, Mamat, Abdullah, and Maad (2012) explained that mathematics is the queen and servant of all sciences. Mahanta and Islam (2012) emphasized that mathematics has an important role to help solving every activity and daily life activities. In Indonesian education curriculum, mathematics is one of the mandatory skills that must be possessed by students. So that mathematics subject has been studied from elementary school to middle school. As stated in the standards of content for elementary and secondary school education, that mathematics needs to be given to students starting from elementary school so that students have the ability to think logically, analytically, systematically, critically,

creatively, and the ability to work together (Minister Regulations (Permen) No. 22 of 2006).

Likewise, in Minister of Research and Technology Regulations (Permenristek) No. 7 of 2022, mathematics is a compulsory subject to prepare students to become members of community believing and fearing in God the Almighty and having noble character, cultivating character in accordance with Pancasila values, and preparing students to improve their competences so that they are able to live independently and earn further education. Hudojo in Halim and Rasidah (2019) said that mathematics is a tool to develop a way of thinking, thus mathematics is indispensable both for everyday life and in dealing with advances in science and technology. Therefore, mathematics is an important science to be taught in schools.

Many people view mathematics as the most difficult field. Even though it is difficult, everyone should learn it because mathematics is a tool to solve problems in everyday life, like language, reading and writing, and mathematical difficulties have to be overcome as early as possible (Anggara, Priatna, & Juandi 2018). The difficulties experienced by the students resulted making errors in solving mathematics problems (Anggara, 2019). One of them is solving word problems (Anggara, 2020; Wijaya, Ying, Purnama, & Hermita, 2020). Based on PISA (Programme for International Student Assessment) assessment result in 2018, Indonesia earned 371 average score. It was in the 72 ranking of 77 countries and it was far away under the OECD (The Organisation for Economic Co-operation and Development) average score of 487. Novitasari in Marissa and Solahudin (2022) showed that Indonesian students' mathematical problem-solving ability is still low. It was a sign for teachers to modify learning innovation to improve students' ability.

The same situation occurred at MTsN 15 Majalengka. Based on observation conducted in class VII, students' mathematics learning outcomes were still low compare to class average score. Most students still made errors in solving real life situation word problems. One of mathematics topics implemented in word problems is integers. An integer is a number system which is the set of all numbers (not fractions) consisting of positive integers {1,2,3,4, 5,}, zero {0}, negative integers {-1, -2, -3, -4, -5,}. Integers are subsets of rational numbers. Thus, integers include {..., -1, -2, -3,0,1,2, 3,}. The errors made by students included the students were not able to understand the questions correctly, the students were not able to read symbols or mathematical notation correctly so automatically they could not find the important information and the question being asked, the students were not able to implement formulation for answering questions, students were not able to implement arithmetic operations or calculation steps correctly, and the students

did not know or write the correct conclusion as the final answer for each question (Yusnia & Fitriyani, 2017).

Based on Sriati (Sulistyowati, 2015), there are several types of errors in solving mathematics problems. (1) errors in mathematical modeling, (2) errors in understanding mathematical concepts, (3) strategic errors, students choose the wrong way to solve problems, (4) systematic errors, the selection of the wrong extrapolation technique, (5) the sign of an error in marking or mathematical notation, and (6) a calculation error in implementing mathematical operations. Adnyana and Bennu (2019) their research showed the location of students' mathematical errors, both conceptual and procedural. Conceptual errors occur due to misunderstanding problems, application the implementation of operating principles or rules, etc. While procedural errors occur because procedures are incomplete, arbitrary in problem solving, and incorrect in arithmetic operations. Another opinion was also put forward by Tekaeni, Supandi, and Setyawati (2020) the factors cause students' errors in solving word problems; including: (1) question misunderstanding; (2) errors in making mathematical models; and (3) errors in interpreting answers with mathematical expressions.

The number of students making errors was confusing. Students' errors in solving word problems were identified and analyzed to find out what common errors made by the students and the reasons (Yusnia & Fitriyani, 2017). The errors data and errors causes were obtained through the form, so that teachers could provide suitable assistance to students. The research results Nugraha, Kadarisma, and Setiawan (2019) showed that most students understood only certain procedures in studying mathematics so it was very difficult for them when facing problems in different types and it led to errors. According to Widayanti, Rusmawati, and Siswati (2012) problem solving in a cognitive context is described as a mental activity characterized by the representation of an object into a mental picture in the form of symbols, responses, ideas, and values or considerations.

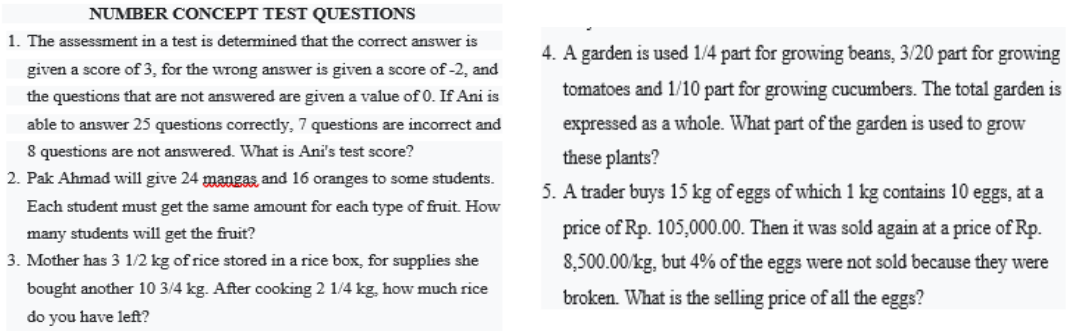
One strategy that can be used to describe the errors made by students in solving word problems is using newman error analysis (Newman, 1977). The newman error analysis was chosen because it has high credibility. Clamen (1980) and Sutama (2021) classified the stages in the newman error analysis into 5 parts, namely reading the problem (reading), understanding the problem (comprehension), transforming the problem (transformation), process skills (process skills errors), and writing the final answer (coding). It was expected that by using newman error analysis the source and form of students' errors in solving word problems would be clear and described in detail.

The Newman Error Analysis Procedure (NEA) has been used by several researchers to analyze mathematical problem-solving errors. For example, Satoto (2013) and Amalia (2017) used the Newman procedure to analyze student errors in solving mathematical word problems. Meanwhile, Susanti (2017) also used the Newman procedure to analyze students errors in solving linear programming word problems. In this research, researcher used newman's five stages of errors ~~a~~ description, although sometimes some students had more than one errors in solving a problem. Therefore, in this research, researcher analyzed more comprehensive errors classifications. All indicators have to be developed in classifying student errors in solving word problems on the number concept. Researcher in this research used modified Newman Error Analysis (NEA) and all indicators were adopted from Clemen (1980) and Oktaviana (2017). The determination of more comprehensive indicators was expected so that the phenomena occurred when students solved number concept on word problems can be read easily and it provided more significant data disclosure. Based on the background, the research purpose was to find out the form of student errors on number concept in solving word problems.

Method

The researcher in this research used descriptive qualitative approach, having main purpose of getting an in-depth description and information about students' errors in solving word problems based on data obtained. The research was conducted on 29 November 2021 and it was continued with interviews on 30 November 2021. The subjects in this research were grade VII students of MTsN 15 Majalengka consisting 21 students. Then 5 students were classified into several categories namely 2 students were in the high category, 1 student was in the moderate category and 2 students were in the low category. They were classified based on the scores they obtained. Based on the classifications above-mentioned, the value range for students having high category is more than and equal to 75 but less than and equal to 95 ($75 \leq x \leq 95$), the value range for students having moderate category is more than and equal to 55 but less than 75 ($55 \leq x \leq 75$) and the value range for students having low category is more than and equal to 45 but less than 55 ($45 \leq x \leq 55$).

The instrument used in this research was word problems question paper consisting five questions as follow (see Figure 1):



NUMBER CONCEPT TEST QUESTIONS

1. The assessment in a test is determined that the correct answer is given a score of 3, for the wrong answer is given a score of -2, and the questions that are not answered are given a value of 0. If Ani is able to answer 25 questions correctly, 7 questions are incorrect and 8 questions are not answered. What is Ani's test score?
2. Pak Ahmad will give 24 mangas and 16 oranges to some students. Each student must get the same amount for each type of fruit. How many students will get the fruit?
3. Mother has 3 1/2 kg of rice stored in a rice box, for supplies she bought another 10 3/4 kg. After cooking 2 1/4 kg, how much rice do you have left?
4. A garden is used 1/4 part for growing beans, 3/20 part for growing tomatoes and 1/10 part for growing cucumbers. The total garden is expressed as a whole. What part of the garden is used to grow these plants?
5. A trader buys 15 kg of eggs of which 1 kg contains 10 eggs, at a price of Rp. 105,000.00. Then it was sold again at a price of Rp. 8,500.00/kg, but 4% of the eggs were not sold because they were broken. What is the selling price of all the eggs?

Figure 1. Instrument of Number Concept Questions

The results of students' work showed how big the percentage of student errors is. Sutejo (2001) stated that to find out the percentage of students' errors types, the following formula can be implemented.

$$\text{Pi} = \frac{n}{N} \times 100\%$$

Annotation:
P = percentage error
i = error type
n = number of errors in each type
N = number of errors for all errors categories

Sutejo (2001) stated that error percentage category is presented in the following Table 1.

Table 1. Error Percentage Category

Percentage	Classification
$K < 10\%$	Very low
$10\% < K < 25\%$	Low
$25\% < K < 40\%$	Moderate
$40\% < K < 55\%$	High
$K \geq 55\%$	Very high

Based on Table 1, the students process in solving problems related to the assessment indicators would be made more specific on the numbers topic by the researcher. From the explanation above, in this research the students' abilities in the process of solving questions related to numbers based on error criteria would be clarified in the following Table 2 (Newman, 1977; Chusnul, Mardiana, & Retno, 2017).

Table 2. Error Criteria According to Newman's Error Analysis

No	Newman Procedure	Cause of Error
1	Reading errors	a. Students cannot read units correctly b. Students cannot read the symbols correctly
2	Comprehension errors	a. Students do not fully understand what known is b. Students do not understand what question being asked is completely
3	Transformation errors	a. Students are not able to make mathematical models from the information obtained b. Students choose the wrong formula or method in solving problems
4	Process skill errors	a. The student is wrong in carrying out the procedures or steps used b. Students are wrong in doing calculations
5	Encoding errors	a. Students are not able to find the final result according to the procedures or steps used b. Students are not able to write the final answer according to what question being asked is

Based on Table 2 above, the five indicators were modified by the researcher and adapted to the needs in this research.

Results

Students errors in completing a test on the number topic were analyzed in the following students' answer sheets:

Subject (1)

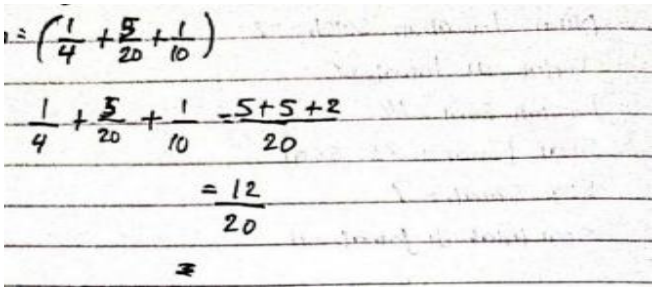


Figure 2. S1 Student's Answer for Problem Number 2

Based on Figure 2, taken from student's answer sheet, subject 1 made errors on the indicators of; (1) process skills errors, namely on questions number 2, 3, and 4. The students did not provide the final answer to simplify the fraction into the simplest form using Highest Common Factor (FPB) and the errors in implementing arithmetic operations; (2) comprehension errors, namely on questions number 3, 4, and 5. The students could not mention what question being asked was; (3) errors in writing the final answer (encoding errors), namely on the answer to question number 5. The students did not provide conclusions from the final answer obtained.

Subject (2)

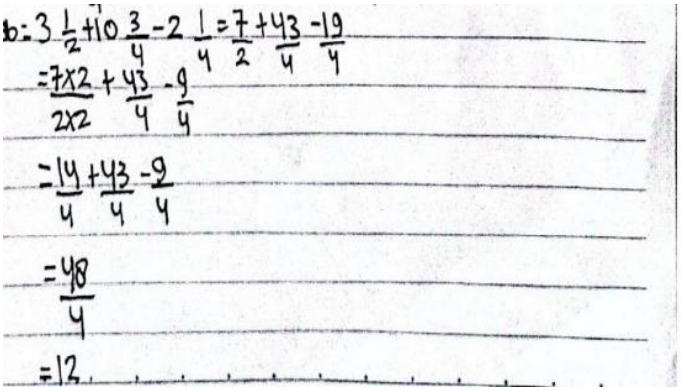


Figure 3. S2 Student's Answer for ProblemNumber 3

Based on Figure 3, taken from Subject 2 student's answer sheet. The errors were on the indicators of; (1) process skills (process skills errors), namely on questions number 2 and 4; (2) understanding the problem, namely on questions number 1, 2, 3, 4 and 5. The student did not understand the question. They could not mention what question being asked in the problem was; (3) writing the final answer (encoding errors), namely on the question number 3; and (4) errors on the

transformation (transformation errors), namely on the question number 5. The students did not write the method or formula down to answer the question.

Subject (3)

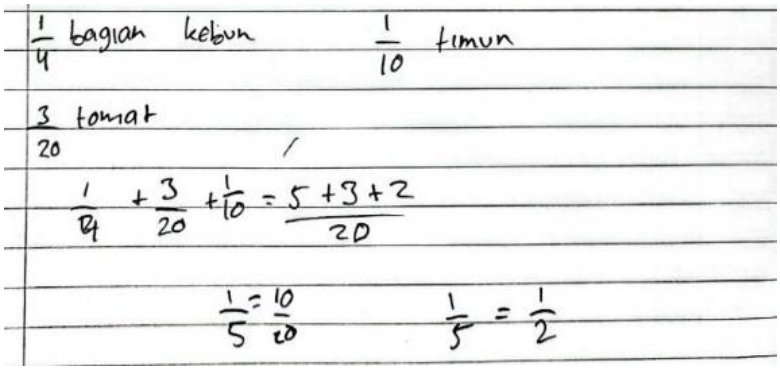


Figure 4. S3 Student's Answer

Based on Figure 4, taken from Subject 2 student's answer sheet, the errors were on the indicators of; (1) process skills (process skills errors), namely on questions number 1, 2 and 3; (2) understanding the problem, namely on questions number 1, 2, 3, 4, and 5. The students did not understand the problem, and they could not mention what question being asked in the problem was; (3) writing the final answer (endcoding errors), namely on question number 3; and (4) errors on transformation (transformation errors), namely on questions number 1, 2, and 5 where the students did not write the method or formula down to solve the problem.

Subject (4)

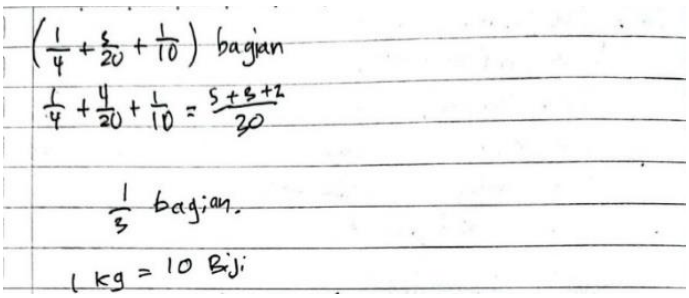


Figure 5. S4 Student's Answer Number 5 Problem

Based on Figure 5, taken from Subject 2 student's answer sheet, the errors were on the indicators of; (1) process skills (process skills errors), namely on questions number 3, 4, and 5; (2) understanding the problem, namely on questions number 2, 3, 4, where the students did not understand the problem, and they could

not understand what question being asked in the problem was; (3) writing the final answer (encoding errors), namely on the questions number 1 and 2.

Subject (5)

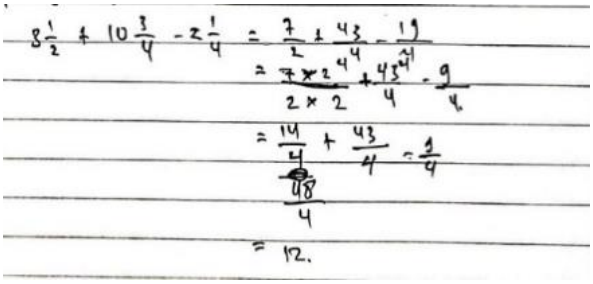


Figure 6. S5 Student's Answer Number 3 Problem

Based on Figure 6, taken from Subject 5 student's answer sheet, the errors were on the indicators of; (1) process skills (process skills errors), namely on questions number 1 and 4; (2) understanding the problem, namely on questions number 1, 2, 3 and 4 where the students did not understand the problem, and they could not mention what question being asked in the problem was; (3) writing the final answer (encoding errors), namely on question number 3; and (4) transformation errors, namely on questions number 1 and 4, where the students did not write the method or formula down to solve the problem.

Each student's answer sheet was checked and compared to the answer keys that have been prepared. After the researchers analyzed and grouped the errors made by the students, the researchers presented the results in tabular form as clearly written in Table 3.

Table 3. Types of Errors Made by the Students

No.	Error Type	Subject
1	a. Reading errors	0
	b. Comprehension errors	S2 S3 S5
	c. Transformation errors	S3
	d. process skills errors	S3 S5
	e. Encoding errors	S3 S5
2	a. Reading errors	0
	b. Comprehension errors	S2 S3 S4 S5
	c. Transformation errors	S2 S3
	d. process skills errors	S1 S2 S3
	e. Encoding errors	S4
3	a. Reading errors	0
	b. Comprehension errors	S1 S2 S3 S4 S5
	c. Transformation errors	S1 S3 S4
	d. process skills errors	S3 S4
	e. Encoding errors	S2 S3 S4 S5
4	a. Reading errors	0
	b. Comprehension errors	S1 S2 S3 S5
	c. Transformation errors	S5
	d. process skills errors	S1 S2
	e. Encoding errors	S1 S3 S4 S5
5	a. Reading errors	0
	b. Comprehension errors	S2 S3
	c. Transformation errors	S2
	d. process skills errors	S4 S5
	e. Encoding errors	S1

Based on Table 3, the results obtained from the translation of students' errors using newman procedure were concluded in Table 4 below.

Table 4. Results of Students' Ability Percentage

No	Error Type	Persentage	Category
1	Reading Errors	0,00%	Very Low
2	Comprehension Errors	0,38%	Moderate
3	Transformation Errors	0,16%	Low
4	Process Skills Errors	0,22%	Low
5	Encoding Errors	0,24%	Low

Based on the Table 4, it was written clearly that comprehension errors were the most common errors and students' difficulties. It was in line with the results of Anggara's research (2021). The number topic was often be students' difficulty and it led to be fatal mistake in understanding more complex mathematics topics.

Discussion

Based on the research results, some students' had some errors in answering word problems on number topic based on newman's analysis. The reading errors indicator shows 0.00% with a very low category. It means that no errors made by the students in the reading errors indicator. The comprehension errors indicator shows 0.38%. It means that some make errors and it is in moderate category. The transformation errors indicator shows 0.16%. It shows that some students make some errors and it is in low category. For the process kkills indicator, it shows 0.22%. It means that some students make errors and it is in low category, and for the last indicator, writing errors or encoding errors, the students make 0.24% for the errors and it is in low category.

From the results above, the biggest number of errors was found in the comprehension errors indicator 0.38%, for moderate category. In general, based on newman's 5 errors indicators, students made errors based on only 4 indicators, namely comprehension errors, transformation errors, process skills errors and encoding errors. This is in accordance with White's opinion (2018). Student's errors in working on math word problems occur at the Newman stage, namely: reading errors (reading stage errors), comprehension errors (understanding stage errors), transformation error (transformation stage error), process skills error (process skill stage errors) and encoding errors (final answer writing stage errors). Based on the opinion above, it can be concluded that the five stages of the newman procedures can cause errors when students solve math word problems. This is inseparable from the object of mathematical study itself so that the type of errors will be reviewed from the mathematical object in the form of facts, concepts, skills (operations) and principles.

The factors cause errors at the stage are; (1) understanding the problem. Students were not accustomed to writing information known and the question being asked on the answer sheet. They had some reasons for example they thought that it was not necessary, they did not understand the meaning of some words or sentences in the question, they forgot to write because they lacked of time; (2) transformation problem. Students were not careful in understanding the problem and they did not pay attention on the units of each number. They did not understand overall meaning of the words contained in the question. They did not remember related topic and the students lacked of knowledge in making mathematical models because they lacked of practice; (3) process skills stage. Errors made by students in the previous stage produced errors in this stage; (4) writing the final answer. In this stage, almost all students made errors. It was because of the errors made by students in the previous stage. The results were automatically incorrect and finally

they ignored writing the conclusion. Other reasons found that they lacked of time and they thought writing conclusion is unnecessary thing. Writing conclusion related to writing final answer so when they did not write conclusion, they did not write final answer as well.

The carefulness was not the main cause of making errors but they were in rush or they lack of time. This fact is based on (Sari & Fortune, 2021). They stated that the cause of making mistakes is not carefulness in solving problems, hasty or being in a hurry, not used to writing complete solutions, lack of study or do not understand the topic, lack of practice, and do not understand the problem.

Conclusion

Based on the research results and discussion, the researcher concluded that students' comprehension on mathematical ability in solving numerical problems was the biggest errors. Meanwhile transformation, process skills, and encoding were not as big difficulties for students. For reading errors, students did not have any serious difficulties. Students' mathematical ability in solving numerical problems could be categorized as good ability. However, some basic errors were still existed and they could be new problems in learning process. The results of this study have limited implications for certain situations. Improvements in learning mathematics could be implemented through several things, one of them is through the analysis of students' learning difficulties number concept.

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