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Analysis of Student Errors in Solving Equations and Inequalities Problems in Algebra and Trigonometry Based on Newman Procedure

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ABSTRACT

The purpose of this study is to examine how students make mistakes when attempting to solve equality and inequality problems in trigonometry and algebra using the Newman method. A qualitative descriptive research methodology is employed in this study. Students enrolled in Manado State University's 2023–2024 Mathematics Education Study Program during their first semester served as the research subjects. Test and interview techniques are used in data collection. Three steps made up the data analysis in this study: reduction, data display, and data verification. Data analysis utilizing the Newman approach yielded the following conclusions: 5.6% encoding errors, 4.8% reading errors, 12% comprehension errors, 8.4% transformation errors, and 18.8% process skill errors were made when solving equation and inequality problems. The inability of pupils to comprehend the concept of the subject being explained, their lack of willingness to study, and their carelessness when reading and completing questions are the causes contributing to these blunders.

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INTRODUCTION

One of the subject areas of expertise in the FMIPAK Mathematics Education study program at Manado State University is algebra and trigonometry. Algebra and trigonometry are courses that students must program, especially in the first semester of the Mathematics Education Study Program, with 3 credits. This course aims to enable students to understand basic mathematical concepts involving number systems, exponents and logarithms, equations and inequalities as well as various material about trigonometry. Algebra and trigonometry are also prerequisite courses for several courses in the following semester, for example differential calculus and analytical geometry. Students are required to master the material of this course

well so that of course it will be easier for students to learn the various materials that will be programmed in the following semester.

Students who have a good understanding of mathematical concepts in Senior High School (SMA) will more easily understand and study various topics presented in algebra and trigonometry. Because students have actually studied algebra and trigonometry material at high school level and have even been introduced to junior high school (SMP). On the other hand, students who do not properly understand the concepts of mathematics at the high school level will experience difficulties in algebra and trigonometry courses.

Daswarman (2020) explains that students' difficulties in understanding concepts or solving mathematics problems are due to students' views on mathematics lessons themselves. One of the reasons for students' lack of understanding of concepts is also due to students' low motivation in learning (Muhammad & Karso, 2018). Farhan & Zulkarnain (2019) also stated that students' low initial knowledge and mastery of mathematics can cause them to feel lazy about studying. Sari (2023) further explained that students' mistakes in solving mathematics problems were caused by a lack of understanding of the questions and material provided, a lack of accuracy in carrying out the calculation process and a lack of practice in working on various questions. This is also supported by the results of the researcher's interviews with first semester students, that during the lecture process almost all students did not study or review the algebra and trigonometry material taught at the meeting. Students only work on questions during lectures and have no intention of practicing other questions that have different levels of difficulty.

Students' errors and difficulties in solving equations and inequalities, especially in algebra and trigonometry courses, are still common and often encountered. Therefore, it is necessary to carry out error analysis on student answers. Error analysis aims to find out the actual situation and is based on the analysis of people who are learning with a clear object (Pinahayu et al., 2023). According to Astuty (2013) error analysis itself is a way to group or find errors using more specific rules. The same opinion has also been expressed by Setiawan et al. (2018) which states that an assessment of errors or inaccuracies in a previously established procedure is to find out the error. The purpose of this error analysis is to evaluate learning and to find solutions so that student mistakes do not drag on and the desired learning objectives can be carried out well.

One of the methods that can be used to analyze student errors in working on equations and inequalities in algebra and trigonometry courses is the Newman procedure. According to Rachmawati et al. (2023) error analysis using

the Newman procedure has good credibility in identifying student errors in doing mathematics assignments. Through the Newman Procedure too, types of errors can be found and identified step by step (Laoli et al., 2023). Error Analysis based on the newman procedure also provides a framework for determining the underlying reasons the difficulties experienced by students in solving mathematics problems and the processes that help teachers to determine errors. In addition, an error analysis based on the Newman procedure provides instructions for lecturers to direct innovative and more effective learning strategies in overcoming student difficulties (Sundayana & Parani, 2023).

In the Newman procedure there are 5 categories in analyzing errors, namely 1) reading errors, 2) errors in understanding the problem (comprehension errors), 3) transformation errors, 4) calculation errors (process skill errors), and 5) errors in writing the final answer (encoding errors) (Daswarman, 2020). According to Jha, (2012), reading errors occur when students cannot read all the words and symbols in the problem. Comprehension errors occur when students are able to read the question correctly but do not understand the meaning of the words read as a whole. Transformation errors occur when students cannot identify arithmetic operations or a series of arithmetic operations. Process skill errors occur when students are able to identify appropriate calculation operations, but cannot carry out these calculation operations. Meanwhile, encoding errors occur when students are able to work out a solution to a problem, but cannot express the solution in an acceptable written form. The same opinion was expressed by Delarosa & Pujiastuti (2023) who stated that the error analysis method based on the Newman Error Analysis problem solving stages consists of: (1) Reading errors: Student errors occur at the stage of reading or understanding mathematics problems. Students may misread instructions, ignore important information, or not understand the context of the problem. (2) Comprehension error: Student errors occur at the stage of understanding the mathematical concepts related to the problem. Students may have an inaccurate or limited understanding of relevant concepts, resulting in errors in applying these concepts in solving problems. (3) Transformation error: Student errors occur at the stage of transforming the information in the problem into an appropriate mathematical representation. Students may have difficulty connecting concepts with relevant mathematical symbols, or make errors in performing calculations or manipulating mathematical symbols. (4) Process skill error: Student errors occur at the stage of using mathematical process skills needed to solve problems. Students may not understand or incorrectly use the steps or

strategies required in solving mathematical problems. (5) Encoding error: Student errors occur at the stage of communicating their solutions or answers. Students may fail to present answers clearly and systematically, or make writing or grammatical errors that interfere with understanding the solution.

The use of the Newman procedure was carried out by Annisa & Kartini (2021) whose research showed that the highest percentage of errors in process skills was 44% and the lowest error was in writing answers 9% with sequence and series material at SMAN 1 Hulu Kuantan. Research by Rahmawati & Permata (2018) also shows that data analysis from the Newman procedure at SMAN 1 Wonosari showed that the highest error was in understanding errors, namely 81.67% and the lowest error was in reading errors, namely 23.33%. Furthermore, research by Sari (2023) results suggest that the highest type of error occurs when students solve applied mathematics problems, namely at the transformation and process skill stages. (Daswarman, 2020) in his research also found that PGSD FKIP students at Bung Hatta University made mistakes in terms of the Newman procedure, namely the highest error was a calculation error and the lowest error was an error in writing the answer. The results of previous research by Mursyidah et al., (2023) also showed that students still make mistakes in terms of the Newman procedure, namely reading errors made by students with low abilities. Misunderstandings and transformation errors are made by students with low and medium abilities. Meanwhile, process skill errors and final answer writing errors were made by students with medium and high abilities.

Based on previous research that has been conducted, no researcher has examined the analysis of student errors, especially in solving equations and inequalities in algebra and trigonometry courses. By knowing the types of students' errors in equations and inequalities, it is hoped that this will become evaluation material for both students and lecturers. So that in the future it will motivate lecturers to create innovations in learning, especially in the field of mathematics, so that students can solve mathematics problems well.

Based on the description outlined above, this article aims to describe the mistakes made by students of the Mathematics Education study program, Department of Mathematics, Manado State University in solving equations and inequalities in algebra and trigonometry courses in terms of the Newman procedure.

RESEARCH METHODE

Qualitative descriptive research is the method of this research. The aim is to learn something optimally to describe, explain and answer in detail the

problems being studied (Sugiyono, 2022). This research explains the mistakes students make when working on mathematics problems and the causes of the mistakes they make, especially in equations and inequalities in algebra and trigonometry courses. The subjects of this research were students in the first semester of the Mathematics Education Study Program, Manado State University odd 2023/2024, totaling 25 students. Sampling used a purposive sampling technique, namely Class 30233108-3 was selected, taking into account the class the researcher taught in. The research instrument was test questions on equations and inequalities in algebra and trigonometry courses as well as interview guidelines. The data collection technique in this research uses tests in the form of Mid-Semester Examination (UTS) questions which are carried out in the eighth week of lectures in the odd semester 2023/2024 and interviews. Interviews were conducted with students in order to find out what factors caused students to make mistakes in solving questions.

The research procedure consists of the preparation stage (the researcher makes observations), the implementation stage (the researcher takes data), and the final stage (the researcher draws conclusions). Data analysis carried out in this research includes several stages, namely reduction, data presentation, and data verification. Data reduction is the stage of determining student test results in which there are many errors and the errors vary. Data presentation is the stage where student test and interview results are analyzed regarding errors in solving questions. And at the data verification stage, conclusions are drawn regarding the test and interview results that have been analyzed.

RESULT AND DISCUSSION

Researchers gave students a Mid-Semester Examination (UTS) of 5 questions on equations and inequalities with a time limit of 100 minutes. Based on the results of the tests carried out by students, there were several errors. The location of the students' errors were grouped according to Newman's procedure, namely reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors. Calculation of the error percentage for each question item uses a modified formula from Trianto, (2009)

$$F = \frac{A}{B}\ x\ 100\ \%$$

Description :

F = error percentage

A = proportion of students who answered incorrectly

B = number of students

A recapitulation of student errors can be seen in Table 1 and Table 2.

Journal of Education and Teaching Learning (JETL)
Volume 6, Issue 1, January 2024
Page 25-40

Table 1.
Student Errors in Solving Equations and Inequalities

Error Type	Question Number									
	1a	1b	2	3a	3b	4a	4b	5a	5b	5c
Error I	1	-	-	-	-	1	1	4	2	3
Error II	-	1	5	3	4	3	4	6	-	4
Error III	-	5	1	2	3	1	4	2	3	-
Error IV	2	4	3	5	4	6	7	9	4	3
Error V	-	3	-	2	2	2	1	4	1	1

Based on table 1 above, in error 1 (reading errors) there was one student who made an error in questions number 1a, 4a, and 4b, four students in question number 5a, two students in question number 5b, and 3 students in question number 5c. Error 2 (comprehension errors) there was one student who made an error in question number 1b, five students in question number 2, three students in question number 3a and 4a, four students in question number 3b, 4b, and 5c, and six students in question number 5a. Error 3 (transformation errors) there were five students who made errors in question number 1b, one student in question number 2 and 4a, two students in question number 3a and 5a, three students in question number 3b and 5b, and four students in question number 4b. Error IV (process skill errors) there were two students who made mistakes on question number 1a, four students on question number 1b, 3b, and 5b, three students on question number 2 and 5c, five students on question number 3a, six students on question number 4a, seven students in number 4b, and nine students in question number 5a. Error V (encoding error) There were three students who made errors in question number 1b, two students in question number 3a, 3b, and 4a, one student in question number 4b, 5b, and 5c, and four students in question number 5a.

Table 2.
Percentage of Student Errors in Solving Equations and Inequalities

Error Type	Question Number										Average
	1a	1b	2	3a	3b	4a	4b	5a	5b	5c	
Error I	4%	-	-	-	-	4%	4%	16%	8%	12%	4,8%
Error II	-	4%	20%	12%	16%	12%	16%	24%	-	16%	12%
Error III	-	20%	4%	8%	12%	4%	16%	8%	12%	-	8,4%
Error IV	8%	16%	12%	20%	16%	24%	28%	36%	16%	12%	18,8%
Error V	-	12%	-	8%	8%	8%	4%	8%	4%	4%	5,6%

Description :

Error I = reading errors
Error II = error in understanding the problem (comprehension errors)
Error III = transformation error
Error IV = calculation error (process skill errors)
Error V = error in writing the final answer (encoding errors)

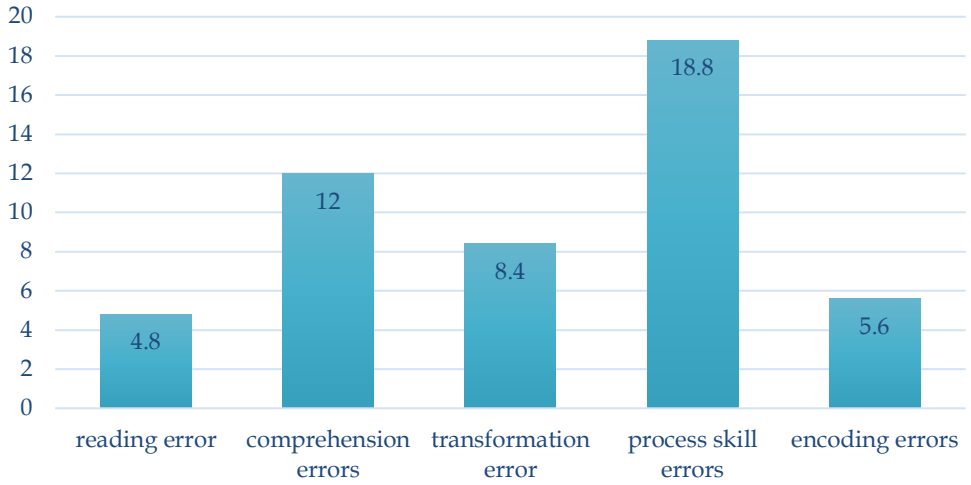

Figure 1.
Percentage of Error Types in the Newman Procedure

Based on the table 2 and figure 1 above, it can be seen that the errors that students often make are 18.8% calculation errors on all questions, namely on questions number 1a, 1b, 2, 3a, 3b, 4a, 4b, 5a, 5b, and 5c; 12% errors in understanding the problem in questions number 1b, 2, 3a, 3b, 4a, 4b, 5a, and 5c; transformation error of 8.4% in questions number 1b, 2, 3a, 3b, 4a, 4b, 5a, and 5b; errors in writing the final answer were 5.6% in questions number 1b, 3a, 3b, 4a, 4b, 5a, 5b, and 5c and finally reading errors were 4.8% only in questions number 1a, 4a, 4b, 5a, 5b, and 5c.

Some students' mistakes in working on equations and inequalities in terms of the Newman procedure can be seen in the following examples:

Reading errors

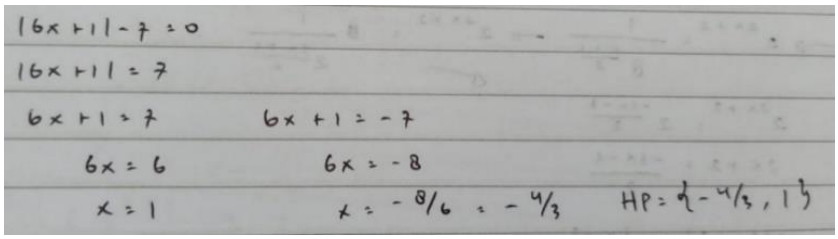

Figure 2.
Student's answer A

The student wrote the question incorrectly, which should have been |6x+1|-7=10 but wrote |6x+1|-7=0. Because of this, it results in student answers not being in accordance with the correct answer key. One of the causes of errors in reading questions is because students lack accuracy in reading the questions given by the lecturer.

Error understanding the problem (comprehension errors)

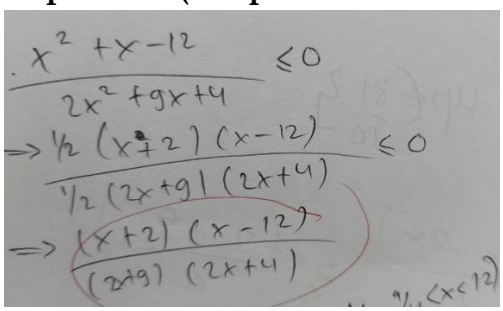

Figure 3.
Student's answer B

Students work on equations incorrectly. In Figure 3 above, the quadratic equation in the numerator, namely $(x^2 + x - 12)$ should produce factoring $(x + 4)(x - 3)$ but students answered the factoring incorrectly. Likewise with the quadratic equation in the denominator, an error occurred in the factoring results of the quadratic equation $(2x^2 + 9x + 4)$ which should be $(x + 4)(2x + 1)$ but students also answered incorrectly. This error is because students do not understand the factoring problem. The error in understanding the quadratic equation problem in the question is caused by the students' lack of understanding of the concept of factoring.

Transformation errors

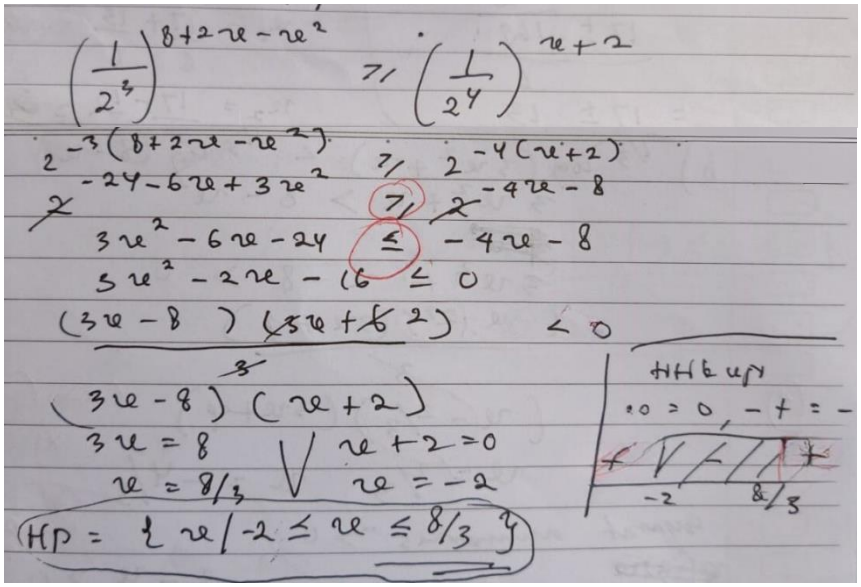

Figure 4.
Student's answer C

Journal of Education and Teaching Learning (JETL)
Volume 6, Issue 1, January 2024
Page 25-40

The problem in Figure 4 is an exponential inequality problem. From the student's work, an error occurred in the wrong part of changing the sign which should remain the inequality sign greater than equal to (≥) but the student changed the inequality sign to less than equal to (≤). Student errors in changing signs result in errors in determining the solution set. Errors occur because students use the wrong formula for exponential inequalities.

Calculation error (process skill errors)

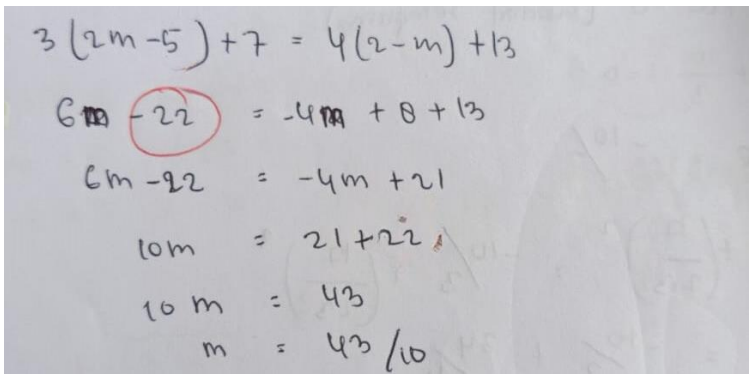

Figure 5.
Student's answer D

In Figure 5, there are calculation errors made by students in the second row. The error in calculating the addition operation is $-15 + 7$. The student should have answered $-15 + 7 = 8$ ut instead calculated incorrectly so he got the answer $-15 + 7 = 22$. Students have understood the concept of equality. However, due to errors in calculations, the answers obtained are less precise.

Error writing the final answer (encoding errors)

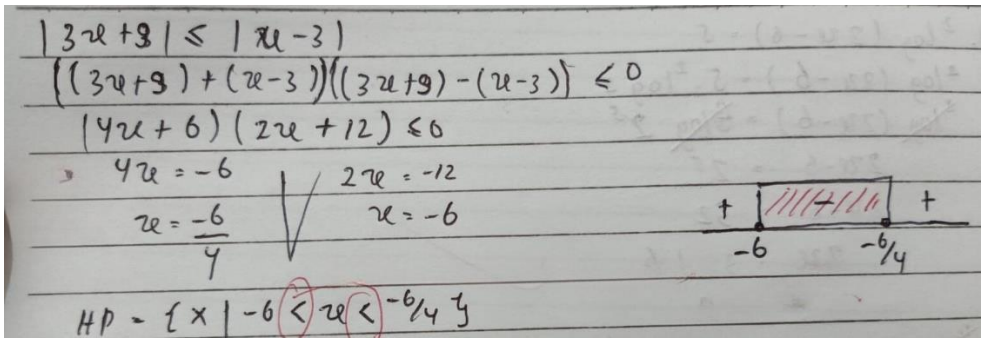

Figure 6.
Student's answer E

From Figure 6, it can be seen that students were correct in solving absolute value inequality questions, but there were errors in writing the final answer. The answer should be $Hp: \left\{x \middle| -6 \leq x \leq -\frac{6}{4}\right\}$, sedangkan mahasiswa menulis $Hp: \left\{x \middle| -6 < x < -\frac{6}{4}\right\}$. This error occurs due to the student's lack of accuracy in

writing the answers, and could also be caused by the student being pressed for time to submit the test.

To find out the causes or reasons why students make mistakes when working on equations and inequalities, interviews are conducted with students. The following is a recap of interviews with students' mistakes in working on equations and inequalities in algebra and trigonometry courses.

1. Reading errors are caused by students' lack of accuracy in solving questions. From one of the interviews, students said they wanted to quickly solve the questions without checking the correct questions again. This lack of accuracy also causes errors in writing students' final answers. Students want to maximize their time working on exam questions so they don't double-check the correct answers.
2. Lack of understanding of the concept causes students to misunderstand the problem and transform the questions given. One of the students interviewed said that they still had difficulty solving factoring problems both from equations and quadratic inequalities because they still lacked basic concepts. Likewise, in transforming problems, students said that too many kinds of equation and inequality questions made them lack understanding and often forgot the basic concepts.
3. Students cannot answer questions correctly. In interviews, several students said they did not understand the material because they were embarrassed to ask questions and did not want to ask when the lecturer explained in class. Students also don't like the material on equations and inequalities, because there are too many types, such as linear equations and inequalities with one variable, quadratic equations and inequalities, rational inequalities, exponential equations and inequalities and many more. This is also one of the causes of students making mistakes in understanding problems and transformations.
4. Lack of student motivation to learn also causes students to make mistakes in solving equations and inequalities. In interviews, several students said that the questions and assignments given by the lecturers were too many. Therefore, lecturers must play an important role in increasing student learning motivation. Lecturers must choose the right method so that students pay attention to the material in class and are more enthusiastic about receiving the material.

Several factors that have been put forward are also supported by research by Sundayana & Parani (2023) which explains that the causes of students making mistakes are a lack of accuracy, a lack of understanding of the situation in the problem, and the habit of not writing down problem solutions. Tanzimah

& Sutrianti, (2023) also stated several things that cause student errors based on the Newman procedure, including not being able to interpret the sentences in the questions correctly, not writing down the information that is known and being asked about the questions, not mastering the steps to solve the questions correctly, and not writing the answer conclusions correctly. Several causes of errors found by researchers need to be studied in more depth and conveyed to students so that students do not make the same mistakes in solving mathematics problems, especially equations and inequalities in algebra and trigonometry courses. Reducing errors made by students in solving questions will have an impact on improving student learning outcomes.

Discussion

Based on the research results obtained, some students still make several mistakes in answering equality and inequality questions in algebra and trigonometry courses. The student's errors were revealed according to Newman's procedure, reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors.

Reading errors made by students were 4.8%. This error has the lowest percentage among other errors in the Newman procedure. The results of this research are in line with research by Dewi & Kartini (2021) which states that the frequency of reading errors is the lowest compared to other errors. After further investigation, reading errors occurred due to students' lack of accuracy in reading questions and lack of understanding of symbols in mathematics. The strategy for minimizing reading errors is that lecturers should often train students to work on questions and train students to be more careful in reading questions.

Comprehension errors made by students were 12%. This error is the second highest error of all errors in the Newman procedure. This error occurs because there are still many students who do not understand the concept and do not understand the purpose of the questions given, especially in lessons about equations and inequalities. After further research, it was found that students did not understand the concept of factoring, causing them to be unable to solve equations and inequalities correctly. This is in line with the opinion of Ada & Kurtuluş (2010) who stated that the error of not understanding the problem in the question was caused by a lack of basic knowledge and concepts of a given problem. This is also in accordance with Singh et al. (2010) opinion that students face more problems in conceptual knowledge than language difficulties when working on mathematics problems. To reduce these errors, lecturers are expected to use interesting learning methods and provide various types of questions so that students better understand the material being taught.

Transformation errors made by students were 8.4%. This error occurs to students because they do not understand the questions given. In interviews it was discovered that students did not know what formula to use so they transformed the questions incorrectly. This agrees with Sundayana & Parani (2023) research, which stated that problem transformation errors occur because they are unable to find concepts that can be used to solve the problem or question given. The solution to this error is to give students different types of questions and more emphasis on important concepts.

Process skill errors made by students were 18.8%. This error is the most common mistake made by students. Based on interviews conducted, many students made calculation errors because they focused too much on concepts and formulas so that the answers they obtained were not accurate. Some students were also less careful in carrying out calculations and did not double-check their explanations. This is in line with Daswarman (2020) research which states that carelessness and the desire to finish quickly as well as a lack of accuracy make students make mistakes in calculating. The solution to this error is that the lecturer must remind you repeatedly to be more careful and recheck the answers obtained. Lecturers must also provide lots of practice questions so that students work diligently on the questions.

Encoding errors made by students were 5.6%. This error also occurs due to students' inaccuracy in working on the questions. The cause of this error is almost the same as the previous error. There are still many students who do not check their explanations again when finished. To minimize these errors, it is an important role for lecturers to tell students to be more careful when working on questions.

CONCLUSION

Based on the analysis and discussion above, it is concluded that students' errors in working on equations and inequalities in algebra and trigonometry courses in terms of the Newman procedure are 4.8% making reading errors, 12% errors in understanding the problem, 8.4% transformation errors, 18, 8% process calculation errors, and 5.6% errors in writing the final answer. The factors that cause student errors are due to lack of attention to and working on questions, lack of understanding and comprehension of the concepts of the material being explained, and lack of motivation to learn.

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