IRJE |Indonesian Research Journal in Education|
|Vol. 7| No. 2|Dec|Year 2023|

# Students' Mathematical Reasoning Errors in Solving Computer Based Written Exam Model Questions Based on Newman's Theory

**HERMINA DISNAWATI[1*], CECILIA NOVIANTI SALSINHA[2], YOHANIS NDAPA DEDA[3], AND NENE LODIANA BEES[4]**

## Abstract

Mathematical reasoning is an essential ability that must be possessed by students when studying at university or in real life. Mathematical reasoning ability is one of the material sub-topics tested in the 2019 computer based written exam. In solving mathematical reasoning content questions, students often make mistakes in answering questions. The mistakes made by students occur due to various factors. Therefore, this research aimed to describe student errors and the factors that caused student errors in solving computer based written exam questions on the topic of mathematical reasoning according to Newman's theory. This research used a mixed method with 28 class XII students as the research subjects. The research instruments were written tests and interviews. The factors that caused reading errors were because students could not interpret the questions properly, misunderstandings occurred because students could not determine the necessary information in the problem, transformation errors occurred because students could not determine the correct method to solve the problem, process skill errors occurred because students were less thorough in solving questions and because of previous mistakes, mistakes in writing the final answer occurred because students were not used to writing conclusions and also because they were in a hurry.

## Keywords

computer based written exam, mathematical reasoning, Newman theory, students' errors

## Article History

Received 30 September 2023
Accepted 18 November 2023

## How to Cite

Disnawati, H., Salsinha, C. N., Deda, Y.N., & Bees, N.L. (2023). Students' mathematical reasoning errors in solving computer based written exam model questions based on Newman's theory. *Indonesian Research Journal in Education |IRJE|, 7*(2), 490 – 501. https://doi.org/10.22437/irje.v7i2.28519

[1]Lecturer at Program Studi Pendidikan Matematika, Universitas Timor, Kefamenanu, Indonesia; Corresponding email: disnawati@unimor.ac.id
[2,3,4] Lecturers at Program Studi Pendidikan Matematika, Universitas Timor, Kefamenanu, Indonesia

## Introduction

One of the issues that always becomes an interesting topic of conversation in the Indonesian education sector every year is the State University Entrance Selection. There are three reasons that college entrance selection is always the hottest issue. First, the quality of graduates at a university can be determined based on the college entrance selection. Second, the form and criteria for college selection will influence the teaching system in schools, and third, the selection to enter tertiary institutions will also influence justice and state regulations. State universities are universities managed by the government, so the quality of State Universities is better.

The large number of students interested in applying to state universities means that enrolling in a state university is difficult. Prospective students must go through several procedures and tests for entrance selection. Simarmata et al. (2022) stated that the computer based written exam is a computer-based or written test whose results will be applied for selection to enter State Universities. When taking part in computer based written exam, participants will try to compete with other participants from various places and schools, due to the large number of participants who are ambitious and competing to take part in computer based written exam, of course, the computer based written exam test is not an easy thing to take because it is carried out very selectively. Simarmata and Ahzan (2021) revealed that during the implementation of computer based written exam every year, only around 20% of participants passed the exam out of the total participants who took the exam.

Based on data from the Ministry of Research, Technology, and Higher Education, the number of participants who passed the 2019 State University Entrance Selection was 23.61 percent of the total number of registrants. For this reason, thorough preparation is needed for the college entrance exam, beginning with a mental and physical comprehension of the subject matter. Based on *Permendikbudristik* number 48 of 2022, which regulates the admission of new students to diploma and undergraduate programs at State Universities, there are differences in the computer based written exam test from the previous year. The primary change in question is that the computer based written exam test in the coming year, namely 2023, will not use *TPS* instead of *TKA*.

In addition to relieving students of the burden of memorization, *TKA* elimination in computer based written exam 2023 allows teachers to concentrate on meaningful learning by removing the need for students to rely on tutoring. The *TPS* topic has always been a topic of the computer based written exam implementation before and after changes were announced in 2023. There are four test topics at *TPS*: the cognitive potential test, mathematical reasoning test, literacy test in Indonesian, and literacy test in English. The content taught at *TPS* is content not covered in school. Even though the material for TPS has not been in schools, *TPS* is usually a test topic in the computer based written exam implementation. It is a challenge for students when taking computer based written exam. They must be more focused and more active in preparing themselves.

Mathematical reasoning ability is one of the material sub-topics tested in computer based written exam before the changes regulated by the Minister of Education and Culture, namely since 2019, and following the announcement that changes would occur in 2023. Reasoning

ability is an important thing that students must have when studying at university or in real life. According to Sumartini (2015), his research stated that reasoning is an activity or thought process to have a method of learning as a strategy that can make it easier for students to master the knowledge that is given or studied. A person can think logically, analytically, and theoretically if he has good reasoning skills. As a thinking activity, reasoning has two characteristics, namely logical and analytical thinking. Mutmainnah et al. (2021) stated that mathematics is understood through reasoning, while reasoning is understood and trained through studying mathematics. According to Tukaryanto et al. (2018), the importance of mathematical reasoning abilities has an impact on the mathematics learning process that students follow. Students will easily understand mathematics if they have good reasoning skills. On the contrary, if they have poor reasoning skills, it will be hard to understand mathematics. To solve mathematical issues, every student needs to have the critical capacity for mathematical reasoning (Hidayati & Widodo, 2015).

In solving mathematical reasoning content questions, students often made a mistake in answering the question. According to Ulfa and Kartini (2021), internal and external influences might impact students' errors when answering questions. In addition, Simarmata et al. (2022) stated that the cause of students' errors in solving computer based written exam questions was that the questions tested in computer based written exam were quite different from what students usually learn and are taught at school. Simarmata and Ahsan (2021) revealed generally, the factor inhibiting students' difficulties in solving mathematical reasoning questions and which will impact students' failure in taking computer based written exam is the lack of introduction to computer based written exam model questions during the learning process at school. By knowing the types of errors in solving mathematical reasoning content questions, students and teachers will be better prepared to take the computer based written exam test in question. An analysis procedure is required to determine the variables that lead to student errors. In carrying out error analysis, one of the theories that can be used as a reference tool in carrying out the analysis is Newman's theory. According to Newman in Syafitri and Kamid (2021), there are five stages in solving mathematical problems, namely reading the problem, understanding the problem (comprehension), transforming the problem, process skills (process skills), and concluding (encoding). Syafitri and Kamid (2021) reported on error analysis of high school students in Ghana in learning trigonometry using Newman error analysis. Hariyani and Aldita (2020) also conducted similar research that shows the types of errors made by class VIIIA students at *SMP PGRI 6* Malang in solving *SPLDV* story questions. The results of previous research show that error analysis needs to be carried out as input for schools, in this case, teachers, to prepare students for the implementation of KBM before students later take part in computer based written exam. By knowing the mistakes students make, at least students will be better prepared to face computer based written exam.

Based on the problems that have been described, it is necessary to analyze the errors made by students based on Newman's error analysis to find out the percentage of students' errors in solving mathematical reasoning problems and the causal factors made by students in solving computer based written exam questions on the topic of mathematical reasoning.

## Methodology

A mixed method was employed in this research to analyze the results of students' work regarding computer based written exam model questions, especially on mathematical reasoning material. The research subjects used in this research were 28 class XII students. For analysis of student work results and interviews, eight students were selected based on the group of students who made the most mistakes, where at each stage of Newman's mistakes, two students were selected to analyze their work results and to interview. The instruments used in the research were written tests and interviews. Written tests help to investigate the types of student errors and the percentage of student errors when solving computer based written exam questions with mathematical reasoning content. Interviews are conducted to analyze students in the test in detail so that there is synchronization between written (student test results) and unwritten (interview results) data. The interview guide used in the research is unstructured. Newman's error indicators (Lusbiantoro, 2016) are in Table 1:

**Table 1.** *Newman error indicators*

| Error's stages | Error's indicator |
|---|---|
| *Reading* | • Cannot read the words proposed in the question. |
| | • Cannot interpret words that are considered difficult in the question. |
| *Comprehension* | • Not writing down what is known and asked in the question. |
| | • Do not understand certain sentences in the questions asked. |
| | • Write down what is known by using the symbols without explanation. |
| | • Write the question asked briefly so that it is not clear. |
| | • Write down what is asked but does not match what is asked in the question. |
| *Transformation* | • Not changing the information in the question into a mathematical sentence and not being able to explain the change process. |
| | • Converting information into mathematical sentences but not correctly. |
| | • It is not appropriate to choose the formula or theory used. |
| *Process skills* | • Errors in computing. |
| | • Do not continue the settlement procedure. |
| | • Did not write the final answer or wrote the final answer incorrectly. |
| *Encoding* | • Write answers that do not fit the context of the question. |

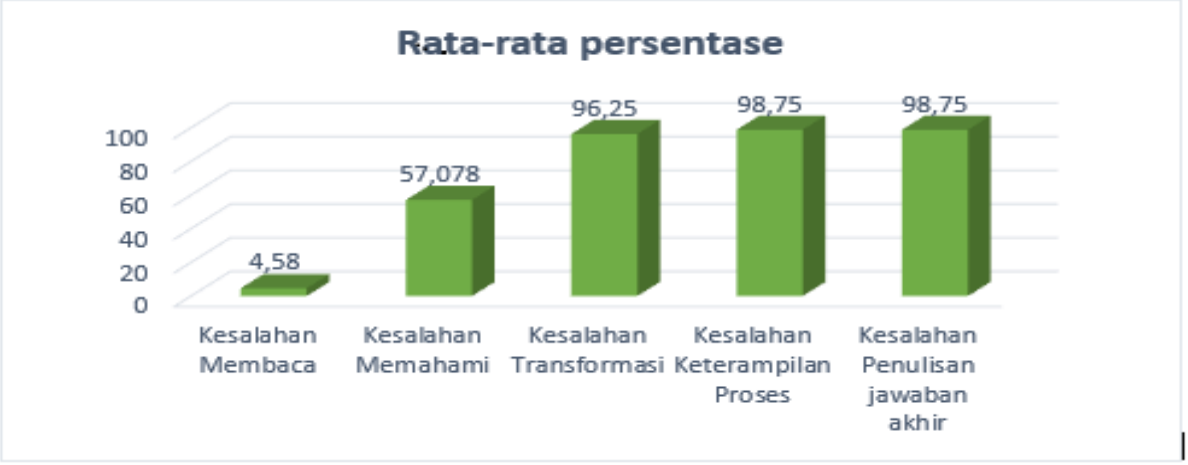
The percentage of student errors in solving test questions is calculated using the formula:

$$\text{Percentages (\%)} = \frac{\text{Number of students which incorrect answer}}{\text{Number of students who answer the questions}} \text{x } 100\%$$

**Findings and Discussion**

Based on data obtained from the results of this research on 28 students of class .25%, process skills errors were 98.75%, and final response writing was 98.75%. Based on the results of this research, the most errors made by students were at the process skills stage and final response writing. It is in line with Nabilah et al. (2021) that the biggest mistakes made by students in solving mathematics story problems based on the Newman procedure were mistakes at the final answer writing stage, while the lowest percentage of errors made by students was at the reading stage, namely amounting to 4.58%. Additionally, Oktaviana (2017) stated that according to Newman's error stages in solving story problems, the fewest errors made by subjects were at the reading stage. The test results showed that students made mistakes at all stages of Newman's mistakes. Student errors when solving questions according to Newman's error stages are not single but multiple and more than one error. The average percentage of students' errors in solving computer based written exam model questions on mathematical reasoning material is in the following figure:

**Figure 1.** *Average percentage of students' errors*

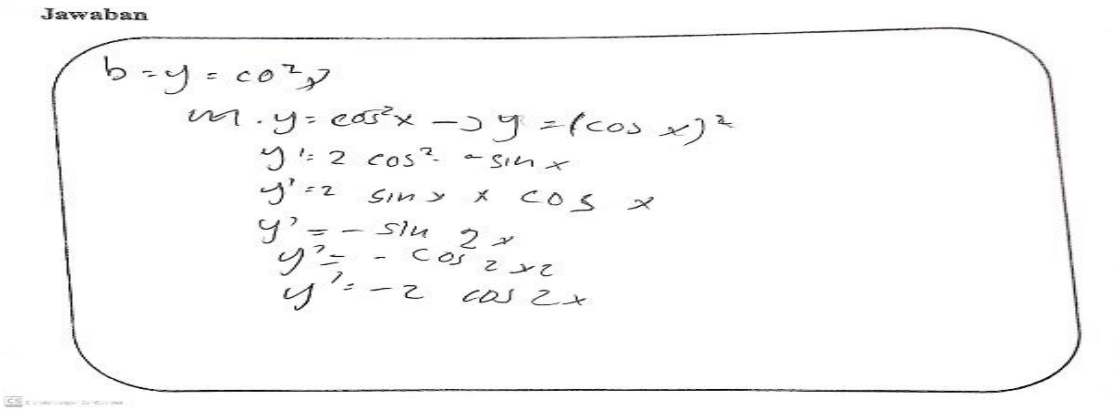



Note: 4,58%= reading errors; 57,07%= understanding errors, 96,25%=transformational errores; 98,75%=process skill errors; 98,75%=errors in writing the final answers

***Analysis of AR Subjects for errors at the reading stage***

Of the 10 question numbers given, the question number with the highest percentage of errors at the reading stage is question number 5. Following are the results of AR's work on question number 5.

**Figure 2.** *Results of work number 5 AR*



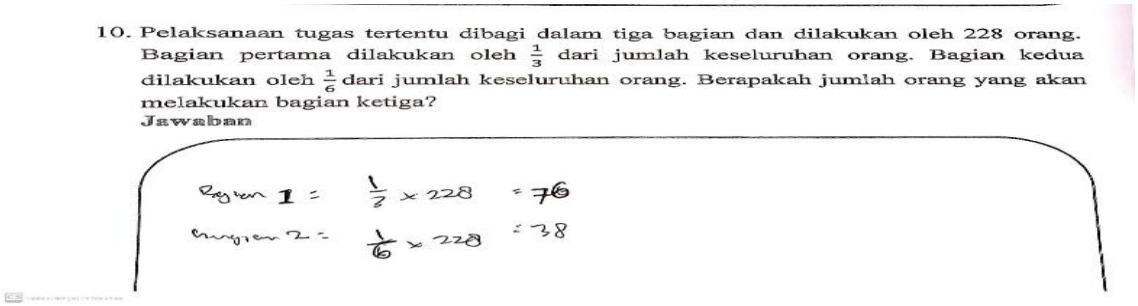

In question number 5, the question format presents data on the percentage of private car users by place of residence. It shows in the question that in 2010, the number of car users was 10% smaller than the actual data. Students were asked to determine in what year the use of private cars was the third highest in villages and cities.

Based on the results of AR's work in Figure 2, according to Newman's error stages, AR made errors at the reading stage, namely in the indicator: students' inability to interpret words that were considered difficult in the question. It can be seen from AR's work on question number 5 and on all the question numbers worked on by AR. AR writes answers that have nothing to do with the question. It means that AR cannot interpret the meaning of the questions given. Apart from reading errors, AR also made errors at other stages, namely the understanding stage, transformation stage, process skills stage, and other aspects.

***Analysis of the CBM subject for errors at the Understanding stage***

Based on the error research results at the understanding stage, the largest percentage of errors occurred in question number 10. The following are the results of CBM's work on question number 10:

**Figure 3.** *Results of work number 10 CBM*



In Figure 3, CBM did not write down the essential information in the questions. According to Newman's error stages, CBM makes errors at the understanding stage, namely in indicators: students do not write down what they know and ask questions. CBM made a mistake at the understanding stage because in the answer he worked on he did not write down what he knew and what was asked in the question. The following is an excerpt from the researcher's interview with CBM:

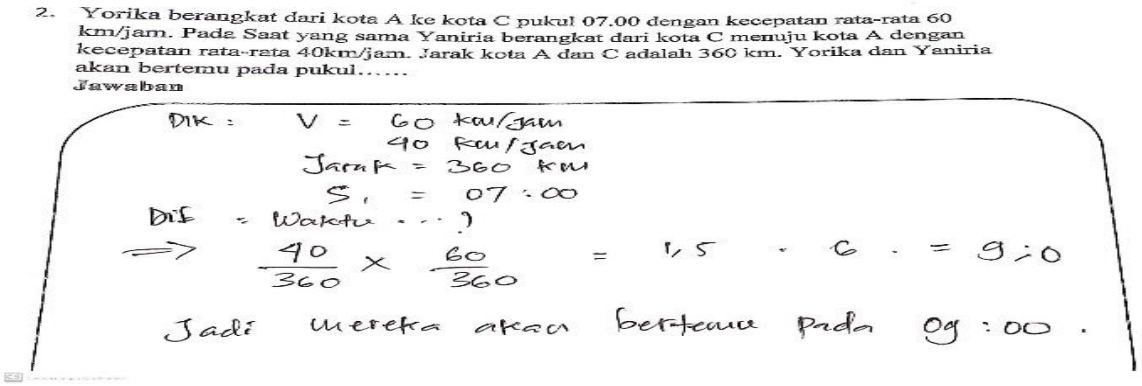
Q: After you read the question, what do you know and what is asked in the question?
S: (mention what is known and ask the question correctly)
Q: Why don't you write down what you know and ask in the questions when you are working?
P: Because it was already number 10, mother, I was in a hurry and forgot to write it

Based on the results of CBM's work and when confirmed through researchers' interviews with subjects, it turned out that CBM's misunderstanding occurred because CBM was in a hurry when working on the questions, so he forgot to write down what he knew and what was asked in the questions. Apart from understanding errors, CBM also makes transformation errors, errors at the process skills stage, and errors at the final answer writing stage.

***Analysis of the DFKS subject for errors in the transformation stage***

Based on the research results, the biggest error in the transformation stage occurred in question 1,2,3,4,5,6,7,8,9, namely 100%. Researchers chose DFKS to represent students who made mistakes at the transformation stage to be interviewed. DFKS is the code name of a student who made a transformation error in question number 2. The following are the results of DFKS' work:

**Figure 4.** *Results of work number 2 DFKS*




From the data in Figure 4, DFKS has written down the work steps up to the conclusion stage, but it turns out that the formula used to solve the problem is not correct or wrong. What is

asked in the question is that students must determine what time the two people will meet, which means that students must know the conditions for the two people to meet and determine the time it will take for them to meet. In this case, according to Newman's error stages, DFKS made a transformation error, namely on the indicator: Shiva was incorrect in choosing the formula or theory used. The following is an excerpt from an interview with DFKS:

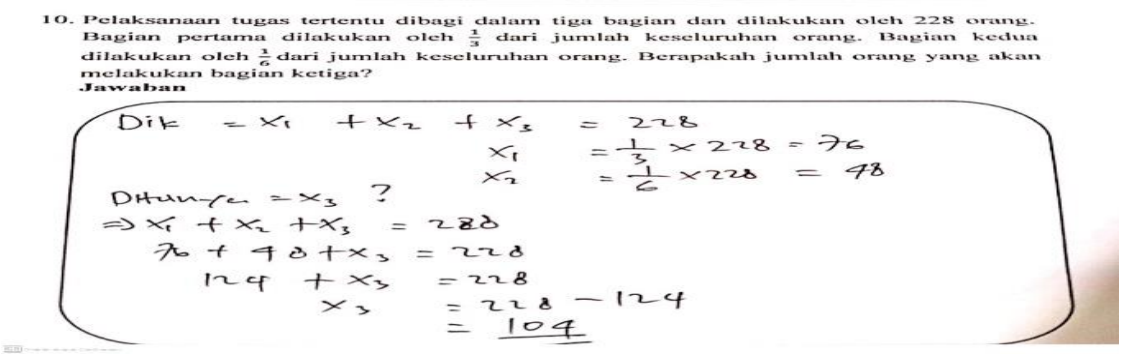
Q: What method did you use to solve this problem?
S: I multiplied 40 x 60 and then divided it by 360 mother
Q: Do you know what the conditions are for them to meet?
S: Don't know, mother
Q: Why do you write important information in the answer that doesn't match the context of the question?
S: I don't know the actual formula, Mom, so I just went straight to normal

The students made transformation errors because of their inability to identify the formula or formulas required to be applied to solve the problem, as was made clear by their work outputs, and confirmed by interviews. It is consistent with research conducted by Nabilah et al. (2021) that one of the causes of students making transformation errors is that students cannot determine and use the correct arithmetic operations or formulas in solving problems. Students experience transformation errors because they cannot identify the operation, algorithm, or formula to use. Apart from errors at the transformation stage, DFKS also made errors at the process skills stage, namely in the indicator: errors in computing. DFKS also made mistakes in writing the final answer, namely in the indicators: students did not write the final answer or wrote incorrectly. Udil et al. (2021) also stated the result of students incorrectly transforming the problem presented in the question causes incorrect processing skills, and, of course, this will also have an incorrect impact on the stage of writing the final answer.

***Analysis of IB for errors at the process skill stage***

IB is the initials of a student who made a mistake at the process skills stage in question number 10. The following are the results of the IB test in question number 10:

**Figure 5.** *Results of work number 10 IB*



According to the data in Figure 4.15, it represents that IB has correctly modeled the problem in mathematics, but at the process skills stage the results turn out that IB did the calculations wrong, so the results of his work were incorrect. The error in question occurred when IB calculated the size of x_2. The result which was supposed to be obtained from this calculation is 38. The following is an exception from an interview with IB:

> Q: What strategy did you use to solve this problem?
> S: I look for the number of people who do task 1 then I look for the number of people who do task 2 then because it is known that the total number of people is 228 then the number of the three groups of people must be equal to 228
> Q: Is it true that one-sixth times 228 equals 48?
> S: Wrong mother, it should be 38
> Q: Why did you write 48?
> S: I was in a hurry so I wasn't careful, Mrs

From the results of IB's work in Figure 5 and when confirmed through interviews, it turns out that based on Newman's error stages, IB made errors at the process skills stage, namely in the indicator: errors in computing. It happens because IB is in a hurry and is not careful when working on the questions. Oktaviana (2017) added that students made process skills errors because they were not careful in the calculation process and were in a hurry when working on questions. Apart from errors in process skills, IB also does not write conclusions. The following means that IB also makes mistakes at the writing stage, the final answer, namely in the indicators: not writing the final answer or writing the final answer but not correctly. PNT analysis for errors at the Final Answer Writing stage. Based on the research results, the largest percentage of errors for the final answer writing stage occurred in question number 7. The researcher chose PNT to represent other students who made mistakes at the final answer writing stage in question number 7 to be interviewed. The following are the results of PNT's work on question number 7:

**Figure 6.** *Results of work number 7 PNT*

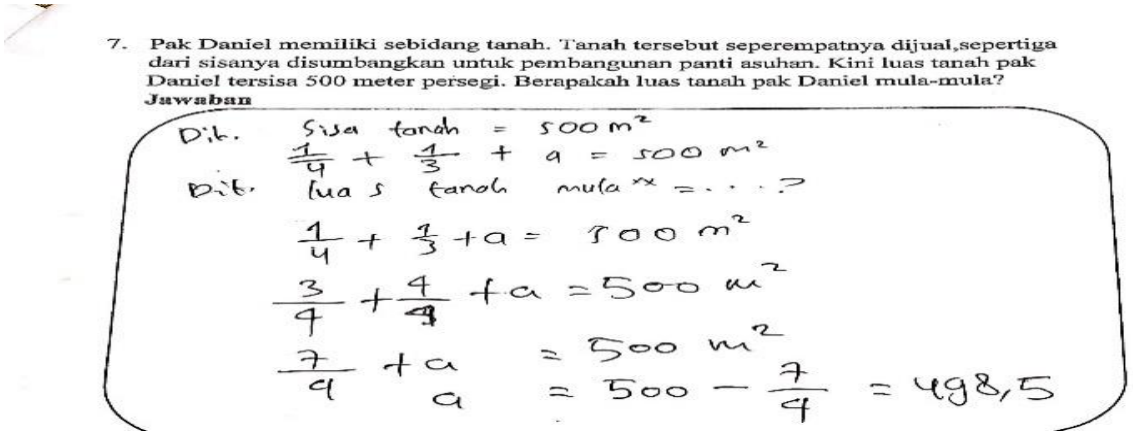


Figure 6 shows that PNT worked on the problem using the formula he used and arrived at the final answer. However, PNT was not correct in modeling the problem in mathematical form. After finding the result, PNT did not write a conclusion. From the results of PNT's work on several questions that he worked on, after searching the results for each question that he worked on, PNT often did not write a conclusion. It also happened in question 7. It turned out that PNT did not write a conclusion. According to Newman's error stages, PNT made errors at the final answer writing stage, namely in the indicators: not writing the final answer or writing an incorrect answer. The following is an excerpt from the researcher's interview with PNT regarding writing the final answer:

Q: Can you explain the steps for the work you wrote?
S: (Silence)
Q: You wrote down one fourth plus one third plus a equals five hundred square meters. What does this mean?
S: I don't understand, mother, so I just wrote it like that
Q: Why don't you write down the final answer after finding the results?
S: because it was already the last numbers, ma'am, so I was in a hurry and forgot to write, Ma'am
Q: Do you always write down the final answer after solving the questions in story form?
S: If I'm not in a hurry, I'll always write to you, Mom.

From the results of PNT's work on question number 7 and when confirmed through interviews, it turned out that an error in writing the final answer was made because PNT was in a hurry when completing the question. It is in line with research conducted by Nurfalah et al. (2021) that the cause of errors at the final answer writing stage was that students were in a hurry when answering the last question because the time to work on the questions was almost running out. Apart from making mistakes at the final answer writing stage, PNT also made mistakes at the previous stages, namely understanding errors, transformation errors, and errors at the process skills stage.

## Conclusion

The conclusion of this research shows that based on Newman's theory, the highest percentage of errors made by students occurred at the process skills stage and the final answer writing stage, namely 98.75%. The results of the research show that the causes of errors at the process skills stage are the consequences of previous errors and the result of students being in a hurry and not being careful in solving questions. The causes of errors at the final answer writing stage are due to previous errors and the result not being used to write final answers when working on story questions. The next largest percentage of errors occurred in the transformation stage, namely 96.25%. The cause of errors at the transformation stage is that the subject does not know and cannot determine the formula that must be used to solve the problem. Furthermore, the largest percentage of errors is followed by errors at the understanding stage, namely 57.078%, and the cause of errors at the understanding stage is

that students are not used to writing down what they know and what is asked in the question, apart from that because students are unable to know the essential information in the question. The smallest percentage of errors occurred at the reading stage, namely 4.58%. The cause of errors at the reading stage is that students do not know the meaning of the questions they will be working on. Teachers should practice mathematics questions more often, especially computer based written exam-type mathematical reasoning questions during teaching and learning activities. It intends to familiarize students with computer based written exam questions so that when facing computer based written exam, students are better prepared mentally and practically.

**References**

Hariyani, S., & Aldita, V. C. (2020). Analisis kesalahan siswa dalam menyelesaikan soal cerita system persamaan linear dua variable berdasarkan prosedur Newman (Analysis of student errors in solving story problems on systems of linear equations in two variables based on the Newman procedure). *Al-khwarizmi: Jurnal Pendidikan Matematika dan Ilmu Pengetahuan Alam, 8*(1), 39-50.

Hidayati, A., & Widodo. S. (2015). Proses penalaran matematis siswa dalam memecahkan masalah Matematika pada materi pokok dimensi tiga berdasarkan kemampuan siswa di SMA Negeri 5 Kediri (Students' mathematical reasoning process in solving mathematical problems on three-dimensional subject matter based on students' abilities at SMA Negeri 5 Kediri). *Repository Publikasi Ilmiah,* 131-143.

Lusbiantoro, R. (2016). Kesalahan siswa dalam menyelesaikan soal ceita berdasarkan Newman Error Analysis terkait kemampuan spasial (Students' errors in solving story questions based on Newman Error Analysis are related to spatial abilities). *Prosiding Seminar Nasional Pendidikan Matematika.* Semarang: UNISSULA Press.

Mutmainnah, A., Putra, Z. H., & Syahrilfuddin, S. (2021). The relationship between fifth grade students number sense and their mathematical problem solving. *PrimaryEdu: Journal of Primary Education, 5*(1), 66-79.

Nabilah, E., Umam, K., Azhar, E., & Purwanto, S. E. (2021). Kecemasan siswa dalam menyelesaikan masalah modelling matematika pada praktek kelas virtual (Students' anxiety in solving mathematical modeling problems in virtual classroom practice). *Internatioinal Journal of Progressive Mathematics Education*, *1*(1), 41-60.

Nurfalah, I. A., Novtiar, C., & Rohaeti, E. E. (2021). Analisis kesalahan siswa berdasarkan kategori Newman dalam menyelesaikan soal materi fungsi. (Analysis of student errors based on Newman categories in solving function material questions) *JPMI (Jurnal Pembelajaran Matematika Inovatif), 4*(1), 205-214.

Oktaviana, D. (2017). Analisis tipe kesalahan berdasarkan teori Newman dalam menyelesaikan soal cerita pada mata kuliah Matematika diskrit (Analysis of error types based on Newman's theory in solving word problems in discrete mathematics courses). *Edu Sains: Jurnal Pendidikan Sains dan Matematika*, *5*(2), 22-32.

Simarmata, J. E., & Ahzan, Z. N. (2021). Bimbingan dan pelatihan penalaran Matematika jenis soal computer based written exam bagi siswa SMA di masa pandemi Covid-19

(Guidance and training in Mathematical reasoning on computer based written exam-type questions for high school students during the Covid-19 pandemic). *Jurnal Pengabdian pada Masyarakat*, *6*(4), 1015-1024.

Simarmata, J. E., Wua Laja, Y. P., Salsinha, C. N., Kehi, Y. J., Laki, A. G., Gomes, M. R., . . . Meti, H. Y. (2022). Pelatihan tes kemampuan akademik bagi siswa SMA kelas XII untuk persiapan computer based written exam sbmptn (Academic ability test training for class XII high school students to prepare for computer based written exam sbmptn). *Jurnal Abdi Insani*, *9*(2), 471-479.

Sumartini, T. S. (2015). Peningkatan kemampuan penalaran matematis siswa melalui pembelajaran berbasis masalah (Increasing students' mathematical reasoning abilities through problem-based learning). *Jurnal Pendidikan Matematika. Mosharafa, 4*(1), 1-10.

Syafitri, V. R., & Kamid, M. (2021). Analisis kesalahan penalaran analogi siswa dalam menyelesaikan soal Matematika dengan menggunakan prosedur Newman ditinjau dari gender (Analysis of students' analogical reasoning errors in solving mathematics problems using the Newman procedure in terms of gender). *Jurnal Pendidikan Matematika, 5*(3), 2998-3008.

Tukaryanto, T., Hendikawati, P., & Nugroho, S. (2018). Peningkatan kemampuan penalaran matematik dan percaya diri siswa kelas X melalui model discovery learning (Increasing the mathematical reasoning abilities and self-confidence of class X students through the discovery learning model). *PRISMA, Prosiding Seminar Nasional Matematika, 1*, 656-662.

Udil, P.A., Senia, M. E., & Lasam, Y. (2021). Analisis kesalahan siswa SD dalam menyelesaikan soal cerita operasi hitung bilangan cacah berdasarkan prosedur Newman (Analysis of elementary school students' errors in solving whole number arithmetic operation story problems based on the Newman procedure). *Jurnal Pendidikan Matematika (Jupitek), 4*(1), 36-46.

Ulfa, D., & Kartini, K. (2021). Analisis kesalahan siswa dalam menyelesaikan soal logaritma menggunakan tahapan kesalahan Kastolan (Analysis of student errors in solving logarithm problems using the Castolan error stages) *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *5*(1). 542-550.

**Biographical Notes**

**HERMINA DISNAWATI is a** lecturer at Program Studi Pendidikan Matematika, Universitas Timor, Kefamenanu, Indonesia.

**CECILIA NOVIANTI SALSINHA is a** lecturer at Program Studi Pendidikan Matematika, Universitas Timor, Kefamenanu, Indonesia.

**YOHANIS NDAPA DEDA is a** lecturer at Program Studi Pendidikan Matematika, Universitas Timor, Kefamenanu, Indonesia.

**NENE LODIANA BEES is a** lecturer at Program Studi Pendidikan Matematika, Universitas Timor, Kefamenanu, Indonesia.