Analysis of Students' Errors in Solving Basic Matrix Operation Problems

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ABSTRACT

Mathematics learning supports the development of students' problem-solving skills, especially matrix material, which has various uses in everyday life. However, students sometimes make mistakes in solving matrix operations. According to Newman's Error Analysis, there are five types of errors made by students, namely errors in reading, understanding, changing meaning, process skills, and final answers. The purpose of this study was to identify students' errors in solving basic matrix operations. Data collection was carried out through test questions and interviews with three 11th grade students as research subjects selected based on purposive sampling, namely the researcher chose subjects considered representative of a population. Students were asked to solve matrix problems and the results of their answers were analyzed based on Newman's Error Analysis. The data analysis technique in this study was qualitative analysis according to Miles and Huberman. Data analysis included three stages, namely data reduction, data presentation, and drawing conclusions. This study showed that students made errors in understanding (6.6%), errors in changing questions (40%), errors in process skills (26.6%), and errors in final answers (13.3%). These errors arise because students have difficulty understanding the problem formulation, determining the steps, and lack of thoroughness in solving the problems. This study suggests implementing learning that focuses on structured practice, using step-by-step problem-solving strategies, and increasing thoroughness so that students can avoid common errors and solve matrix problems more accurately and completely.

Keywords: Newman's Error Analysis; Matrices; Mathematics Learning

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Introduction

Mathematics is a branch of science that is constantly evolving in line with technological advances and the dynamics of human needs. Therefore, mathematics learning is implemented at every level of education, tailored to the abilities and needs of students at each level (Kamarullah, 2017). Mathematics is an essential basic science and contributes significantly to daily life (Fauzi et al., 2021). Munawaroh, Rohaeti, and Aripin (2018) stated that mathematics should be taught from elementary school to university because it is a fundamental science in all fields, essential to understand, and the foundation of science and technology

Mathematics learning is an active activity that involves students in constructing their own understanding of facts, concepts, principles, and skills related to the material being studied (Rahma & Rahaju, 2020). Mathematics learning helps develop students' logical thinking skills, reasoning skills, and intellectual intelligence. In an educational context, the main goal of this learning is to increase thinking capacity and deepen understanding of basic concepts, which form the foundation for mastering mathematics material at a more advanced level (Wandini et al., 2023). According to Komul, Mataheru, and Wattimanela (2023), the goal of mathematics learning is to support students in improving their skills in solving various mathematical problems that are directly related to real-life situations.

In the mathematics learning process, students' interest tends to decline because they perceive mathematics as a subject that requires precision. As a result, they lack a grasp of the concepts taught (Palandeng, et al., 2023). Many students still experience difficulty solving math problems, as evidenced by various types of errors. Based on the findings of Khairani and Kartini (2021), conceptual misunderstanding was the most dominant error, with a percentage of 26.1%. Similar findings were also supported by research by Hermanto and Susilawati (2023), which showed that as many as 65% of students made conceptual errors when solving math problems. This situation reflects that students' mastery of the basic concepts of the material is still not optimal, so they experience obstacles in solving the problems given. In addition to conceptual errors, various types of errors were found, such as errors in operations, symbol use, principle application, and understanding of facts.

The theoretical framework used in analyzing student errors in solving problems is Newman's Error Analysis (NEA), which is an approach that aims to... to identify and classify the types of errors made by students during the process of solving mathematical problems (Nufus et al., 2022). Newman's Error Analysis is a step to understand, transmit, and explain how students answer questions in problems. This is supported by the opinions of Jha (2012) and Komul, Mataheru, and Wattimanela (2023), who stated that Newman recommends five specific activities: reading, understanding, changing, skills in the process, and writing answers.

*Newman Error Analysis*is an approach used to examine errors made by students Halim and Rasidah (2019); Komul, Mataheru, and Wattimanela (2023). Many researchers have utilized the Newman Error Analysis method to analyze errors in solving mathematical problems. One application of error analysis was carried out by Satoto (2013) and Amalia (2017), namely observing student errors in solving word problems, such as errors in reading, understanding, changing questions, process skills, and writing answers. Meanwhile, Susanti (2017) also used the method to analyze errors made by students when solving linear programming word problems. The Newman Error Analysis method is considered to describe the level of errors made by students when solving word problems related to everyday life (Tekaeni et al., 2020).

This study used the NEA method to analyze the errors of eleventh-grade students in solving basic matrix operations. This differs from Satoto et al. (2013) who used NEA to analyze the errors of eleventh-grade students in the topic of distance in geometric shapes. Similarly, Amalia (2017) used the Newman method to analyze student errors in solving word problems and related them to cognitive styles. This study used NEA to describe the errors made by students without relating them to cognitive factors.

Based on this background, this study aims to conduct an in-depth analysis of the error patterns made by eleventh-grade high school students in solving problems related to basic matrix operations. This study uses the Newman's Error Analysis (NEA) approach, focusing on grouping error types into five error categories, namely: reading, understanding questions, transformation, process skills, and writing final answers. Through this analysis, it is hoped that the most dominant types of errors made by students and their causal factors can be identified, so that the results of this study can be a basis for teachers in designing more effective learning strategies and helping students understand the concept of matrix operations more deeply.

Mathematics is crucial for securing lifelong employment in this age of globalization. Therefore, all students must master mathematics at some level to secure decent employment in the future. Mathematics is an essential subject to be taught at every level of education because it serves as the foundation for the development of various other disciplines. (Khairunnisa, 2019). Mathematics learning is part of education that aims to improve the potential and quality of each person.(Putri & Murtiyasa, 2024).

According to Delphie (2009), mathematics is a symbolic system that describes the relationship between numbers and space. According to Karnasih (2015), mathematics helps children understand real-world situations so that they can represent them in mathematical language. Jamilah and Fadillah (2017) state that learning mathematics generally requires high-level cognitive skills, including the ability to analyze, learn, and synthesize. This is not just the ability to recall practical knowledge or apply basic principles (Prengki et al., 2024). According to Tyas, Arjudin, and Dewi (2021), mathematics is one of the most important subjects in education.

In high school or vocational schools, matrices are a branch of algebra taught. They are among the most difficult to learn. A matrix is a rectangular array of numbers arranged in rows and columns, and has properties like ordinary variables, allowing them to be added, subtracted, multiplied, and divided (Edo et al., 2021). Matrices are important to understand because they relate to everyday life and can be used to analyze economic problems involving various variables

(Bahar, et al., 2023). A common problem is that many students make errors in solving matrix operations, reflecting their limited understanding and mastery of the material (Edo et al., 2021).

Anne Newman, a mathematics teacher from Australia, in 1977 introduced Newman's Errors Analysis (NEA) as a way to describe errors. In this process, Newman suggested five very important stages to determine where students make errors when solving a problem: (1) the reading stage is reading and identifying the problem presented, (2) the understanding stage of the meaning of a problem is understanding the meaning of the problem that has been read, (3) the transformation stage is changing the problem in the form of words into a mathematical representation and choosing an appropriate solution strategy, (4) the skill process stage is applying mathematical skills according to the strategy that has been chosen to solve the problem, and (5) the answer reading stage is providing an answer in written form that can be understood (Tekaeni, Supandi, & Setyawati, 2020).

White (2010) in Juniyarti et al. (2024) Newman's Errors Analysis (NEA) is used to understand students' difficulties in completing certain tasks, such as mathematics, and helps teachers design more effective teaching approaches. In mathematics learning, NEA is used to analyze student errors. Research by Candraningsih and Warmi (2023) shows that many students make process skill errors in mathematical word problems, caused by their unfamiliarity with this type of problem. In addition, Siregar et al. (2025) found similar errors in quadratic function word problems, both in process skills and final answers. Therefore, mathematics learning needs to focus on correcting the errors made by students.

The relationship between the background and theoretical study in this article lies in the same focus, namely the importance of mathematics learning and the analysis of student errors in understanding concepts and solving problems. The background highlights students' difficulties in mastering the basic concepts of matrix operations, which lead to various types of errors. The theoretical study then reinforces this by explaining the important role of mathematics in education and the use of Newman's Error Analysis (NEA) as an approach to systematically identify and analyze student errors. Thus, NEA theory serves as a relevant basis for addressing the problems raised in the background and helps improve the effectiveness of mathematics learning.

Method

This study investigates the ability of eleventh-grade students to solve basic matrix operations. This study uses a qualitative descriptive methodology. is a research method that aims to describe facts and phenomena objectively. This research examines problems, habits, and the relationships between elements that occur in society.(Syahrizal & Jailani, 2023)The researchers selected three eleventh-grade students as research subjects. The subjects were selected based on purposive sampling, meaning the researchers selected subjects deemed representative of a population. This study focused on analyzing and demonstrating the errors students made when working on matrix problems. These errors included errors in concepts, principles, and procedures.

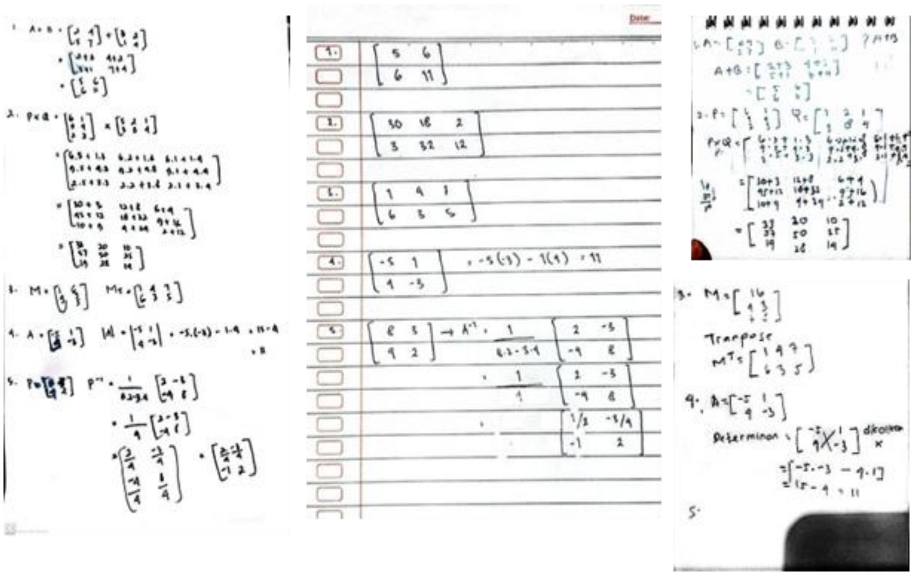
Data collection was conducted in two stages. First, the researcher gave five basic matrix operations problems to the three research subjects. These problems were designed to identify students' abilities in understanding and solving matrix problems, including various types of matrix operations such as addition, multiplication, transpose, determinant, and inverse. After the three subjects completed the problems, the students' answers were documented for analysis by the researcher. In the next stage, the researcher conducted interviews with each subject. These interviews aimed to explore students' understanding, difficulties, strategies, and thought processes in solving basic matrix operations problems.

Newman Error Analysis (NEA) was then used to analyze data from tests and interviews. Sumargiyani et al. (2020) stated that NEA results can help determine appropriate learning methods and approaches and reduce the likelihood of students making errors. Newman Error Analysis divides errors into five categories: reading errors, comprehension errors, question modification errors, process skills errors, and final answers (Putri & Murtiyasa, 2024). The data analysis technique applied was qualitative analysis according to Miles and Huberman, which includes three main stages: data reduction, data presentation, and conclusion drawing (Puspita, et al., 2025). This analysis method helps researchers determine the timing and types of student errors, thus obtaining a clear picture of their difficulties in understanding matrix material.

Results

Reading Error

Figure 1. Student 1, Student 2, and Student 3’s Answer Sheet



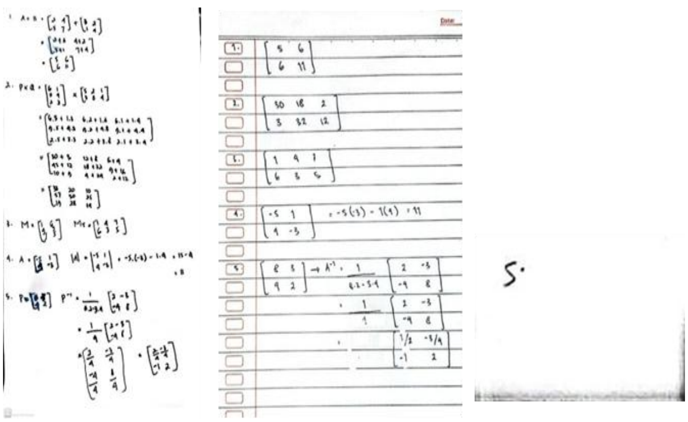
Based on Student 1's answer sheet, the researcher found that he did not make any errors in reading the problem. He was able to recognize the symbols and dimensions of the matrix. An interview with Student 1 revealed that there were no words or sentences in the matrix problem that confused or misunderstood him. Therefore, Student 1 did not experience any difficulties in reading or interpreting the problem instructions. This indicates that Student 1 has a good understanding of the problem language and mathematical notation used.

Based on student 2's answer sheet, the researcher found no errors in reading the questions. Student 2 was able to recognize the symbols, matrix sizes, and follow the question instructions correctly. Based on the interview, student 2 said that sometimes he felt confused when reading matrix problems, especially when he encountered terms such as order and transpose. He admitted that he initially thought ordo meant order, when in fact it meant the size of the matrix. In addition, student 2 also revealed that when the question asked him to "multiply matrix A by B," he sometimes forgot that order in matrix multiplication is important, so he often confused A × B and B × A. This shows that although students were able to read the questions, some technical terms and operating rules in matrices were still confusing.

Based on Student 3's answer sheet, the researcher found that he did not experience any errors in reading the questions. Student 3 was able to recognize mathematical symbols, understand the size or order of matrices, and read and apply matrix addition and multiplication operations well. In addition, he was also able to follow the instructions correctly. However, the student did not provide an answer to question 5, so his ability to read and understand the question on that number could not be determined with certainty. Based on the interview results, Student 3 stated that he had experienced confusion when reading matrix problems in the form of stories, especially when the sentences in the problem were not clearly structured. This proves that although students can read questions that are straightforward, they still have the potential to experience reading difficulties if the problem is presented in narrative form or with unclear sentences.

Comprehension Error

Figure 2. Student 1, Student 2, and Student 3's Answer Sheet



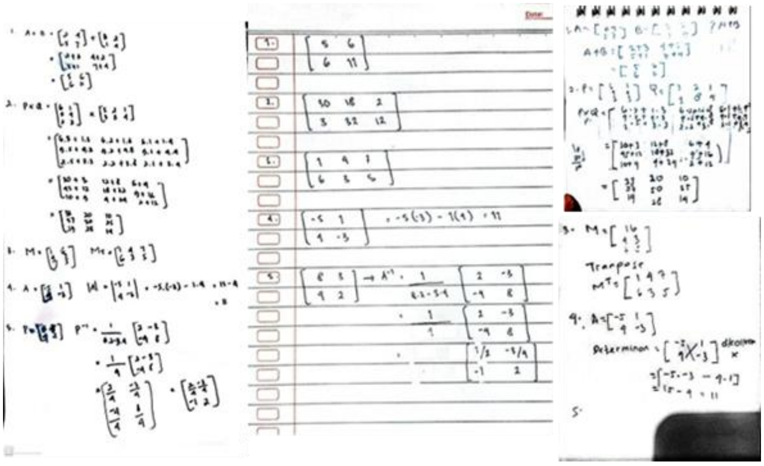
Based on Student 1's answer sheet, the researcher found that he did not experience any errors in understanding the problem. Student 1 demonstrated that he was able to understand the problem addressed in the question. However, when writing his answer, the student immediately worked without writing down the initial information from the question. This indicates that although he understood the question, the student was not yet accustomed to writing complete answers. Thus, it can be concluded that although the student understood the concept, the neatness and completeness of his answer writing still needed improvement.

Based on Student 2's answer sheet, he demonstrated a good understanding of the problem. However, when writing his answer, he immediately jumped into the process of solving the problem without writing down the initial information from the problem. This indicates that despite understanding the problem, he was not yet accustomed to writing complete and coherent answers. Therefore, even though there were no obstacles in understanding the problem, the student's mathematical communication skills still need to be improved to make the answers clearer and more coherent.

Based on the analysis of the answer sheet, student 3 made an error in understanding the questions. Of the five questions tested, student 3 did not answer question 5, so his ability on that question cannot be determined. This absence of an answer may be due to confusion in understanding the concept. Therefore, it can be concluded that understanding of basic concepts needs to be strengthened so that students are more confident and focused in providing answers, even if they are not completely correct.

Transformation Error

Figure 3. Student 1, Student 2, and Student 3's Answer Sheet



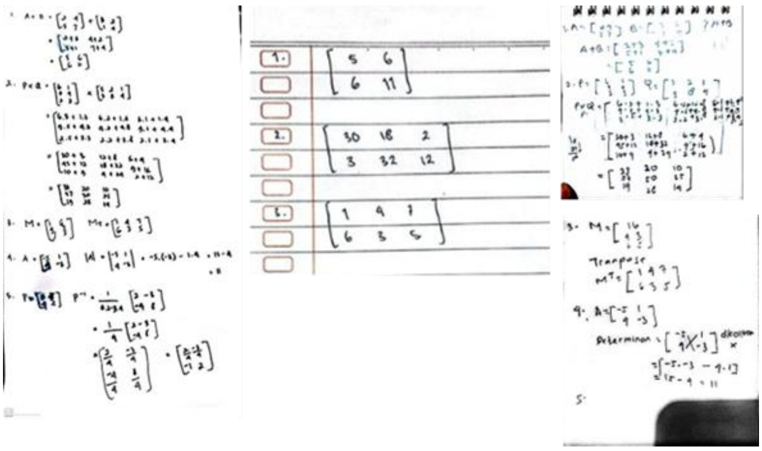
Based on Student 1's answer sheet, researchers found that he was able to convert problems into mathematical models effectively. The student was able to demonstrate the process of converting problems into mathematical models in a coherent manner and in accordance with the concepts requested in the problem. This was evident in how the student wrote the forms of mathematical operations, such as addition, multiplication, transpose, determinants, and inverses. The ability to write mathematical models coherently indicates that the student has a good mastery of basic concepts and can connect the problem text with its mathematical representation.

Based on the analysis of the answer sheet, Student 2 made an error in converting the problem into a mathematical model. Student 2 did not write the complete operation form and immediately jumped to the final answer. This indicates that the student is not yet able to write the problem in the correct mathematical form. This condition indicates that students tend to skip a crucial step in problem solving, namely converting verbal statements into coherent symbolic form.

Based on Student 3's answer sheet, researchers found an error in transforming the problem. For some of the problems, the student was able to write down the steps to solve it, but for Question 5, the student did not provide an answer. Consequently, there was no process of converting the problem into the appropriate mathematical form. According to the researchers, the student may not have understood how to begin solving the problem or not yet mastered the related concepts, thus being unable to identify the appropriate mathematical form to use.

Process Skill Error

Figure 4. Student 1, Student 2, and Student 3's Answer Sheet



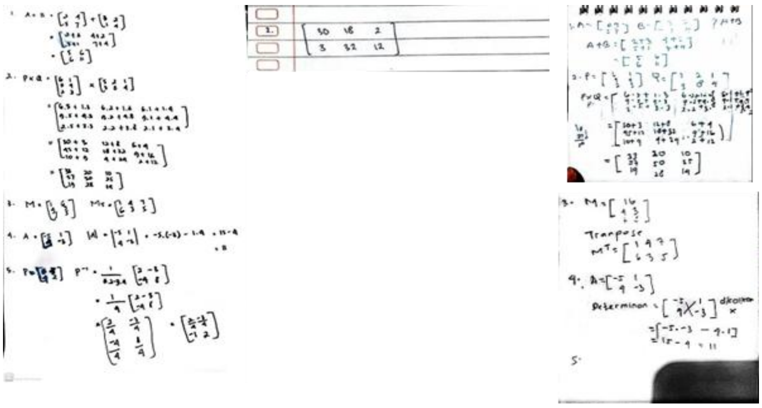
Based on the analysis of the answer sheet, Student 1 demonstrated good problem-solving skills. He was able to demonstrate the process of adding and multiplying two matrices, transposing matrices, finding the determinant, and determining the inverse of a matrix. An interview with Student 1 revealed no difficulties in determining the steps involved. Therefore, Student 1 was able to demonstrate the process of obtaining the answer.

Based on student 2's answer sheet, the researcher found process skill errors. Of the five questions, student 2 did not show the process for questions 1, 2, and 3. This error is shown in the image below. Student 2 should have shown how he obtained the answers to questions numbered 1, 2, and 3. However, he instead wrote the answers directly. This caused the researcher to be unable to assess how the student thought in working on the questions. Based on the interview results, student 2 admitted that he had difficulty in presenting the process of working on the questions. For example, he was confused in determining the first step in working on the questions. Thus, student 2 made a process error caused by his inability to present the process.

Based on Student 3's answer sheet, he committed a process skill error. Of the five questions, he did not answer question 5, resulting in a process error in answering the question. Interviews with Student 3 revealed that he sometimes felt confused about determining the appropriate steps to complete the questions. Therefore, Student 3 committed a process error due to his inability to determine the appropriate steps. The absence of an answer to a particular question also indicates uncertainty or a lack of skill in linking concepts to the required procedures.

Encoding Error

Figure 5. Student 1, Student 2, and Student 3's Answer Sheet



Based on Student 2's answer sheet, the researcher found an error in the final answer. Student 2 incorrectly wrote the correct answer to question 2. This error can be seen in the image below. If Student 2's answer were correct, he should have written that the answer to question 2 is $\begin{bmatrix} 33 & 20 & 10 \\ 57 & 50 & 25 \\ 19 & 28 & 14 \end{bmatrix}$ which measures 3×3. However, student 2 wrote the answer instead $\begin{bmatrix} 30 & 18 & 2 \\ 3 & 32 & 12 \end{bmatrix}$ measuring 2x3. According to the researcher, this error occurs because students make mistakes in the process of working. Based on the interview results, student 2 admitted that he sometimes places elements incorrectly in the matrix. For example, an element that should be in the 2nd row is placed in the 1st column. Thus, student 2 made an error in the final answer caused by his carelessness in working on the problem.

Based on Student 3's answer sheet, researchers found an error in his final answer. Of the five questions, he did not answer number 5, resulting in no final answer being written. As previously explained, Student 3 admitted that he sometimes felt confused about determining the steps to complete the task. This prevented him from writing down his answer to question 5. Therefore, Student 3 made an error in his final answer due to his inability to complete the task.

Discussion

Based on the description above, researchers identified several types of errors that occurred when working on matrix problems. These errors were: understanding errors (6.6%), modification errors (40%), process skill errors (26.6%), and final answer errors (13.3%). High-level subjects did not show any errors in working on the problems. This demonstrates their ability to complete basic matrix operations well. Furthermore, moderate-level subjects showed errors in understanding and modifying the problems due to confusion with the wording or sentence structure. Low-level subjects made errors in modifying the problems and final answers. This was due to their difficulty in determining the steps to be taken. Thus, the most dominant error was the error in modifying the problems.

This is in accordance with the opinion of Sari and Pujiastuti (2022) that student errors occur not only in calculations, but also from the initial stage of converting problems into mathematical form, such as misunderstanding instructions, using concepts, or choosing formulas. In line with this, research conducted by Nitbani, Amsikan, and Klau (2022) showed that students made many errors at the transformation stage (61.15%) when converting story problems into mathematical models, characterized by the inability to choose the correct formula, symbol errors, and failure to convert problem information into the correct mathematical form. Furthermore, research by Palandeng, Tumalun, and Wenas (2023) also found transformation errors of 24%, when students were unable to determine the correct operation or formula, such as the conditions for matrix multiplication or writing determinants.

Based on interviews with all subjects, they admitted to experiencing difficulties in completing the test questions. Students lacked a grasp of matrix terms, such as order and transpose. Students were also sometimes confused about determining the steps to solve the problems. Furthermore, students were sometimes careless in completing the problems. Therefore, the causes of errors in completing basic matrix operations were difficulty understanding the terms and wording of the problems, difficulty with the steps, and a lack of thoroughness in completing the problems.

Based on this research, the researcher hopes that further research can expand upon it. This is important because the number of subjects included in this study was still limited to three students. Therefore, future researchers are advised to increase the number of subjects to obtain more varied and in-depth data. Furthermore, further research can examine other factors that influence errors and explore effective learning models to minimize student errors in solving basic matrix operations.

Conclusion

Based on the research results, it can be concluded that the most common error made by students when solving basic matrix operations is the error in converting the problem into mathematical form. This error is generally caused by students' inability to understand the problem instructions, select the correct formula, and convert the information into the correct mathematical form. Furthermore, errors in comprehension, errors in process skills, and errors in final answers were also found, with a lower percentage.

The main causes of these errors stem from students' difficulty understanding the terms used in matrix material, confusion in determining solution steps, and a lack of thoroughness when working on the problems. Interview results also supported this finding, with most students admitting they didn't fully grasp basic concepts like order and transpose. These findings indicate that students' conceptual understanding and thoroughness still need to be improved to reduce errors in solving matrix problems.

Based on the research findings, it is recommended that teachers place greater emphasis on the problem transformation stage by encouraging students to write mathematical models correctly, understand basic matrix terms, and practice accuracy. Students should read problems carefully, write down the steps sequentially, practice more, and double-check their work. Future researchers are advised to expand the number of subjects, examine other factors that influence errors, and assess the effectiveness of learning models in minimizing student errors in matrix operations.

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