



ANALYSIS OF STUDENTS' DIFFICULTIES IN SOLVING MATRIX OPERATIONS PROBLEMS

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Abstract

This study aims to analyze students' difficulties in solving matrix operation problems among Grade XI MIA 2 students at MAN 4 Aceh Besar. The identified difficulties include understanding concepts, using mathematical symbols, comprehending problems, and drawing conclusions. This research was motivated by students' low mastery of basic matrix operations such as addition, subtraction, multiplication, identity matrices, determinants, and inverses of 2×2 matrices, indicating weak conceptual understanding. A qualitative descriptive approach was employed with 27 students as research subjects. Data were collected through written tests, interviews, and documentation, and analyzed using the Miles and Huberman model, consisting of data reduction, data display, and conclusion drawing. Written test results were analyzed based on difficulty indicators and supported by interviews with students who obtained low scores. The findings show that conceptual understanding difficulties were the most dominant (51.8%), reflected in errors in determining matrix order, applying row-column operations, and using determinant and inverse formulas. Errors in concluding accounted for 33.3%, while difficulties in using symbols and understanding problems reached 29.6%. These difficulties were caused by weak basic concepts, lack of accuracy, limited practice, and challenges in interpreting word problems. The study concludes that improving students' understanding of matrix operations requires student-centred learning, visual media, structured practice, and guidance that emphasises procedural accuracy.

Keywords: Conceptual Understanding; Matrix Operations; Students' Difficulties

Abstrak

Penelitian ini bertujuan untuk menganalisis kesulitan siswa dalam menyelesaikan soal operasi matriks pada siswa kelas XI MIA 2 MAN 4 Aceh Besar. Kesulitan yang dikaji meliputi kesulitan memahami konsep, penggunaan simbol matematika, memahami soal, dan menarik kesimpulan. Penelitian ini dilatarbelakangi oleh rendahnya penguasaan siswa terhadap operasi matriks dasar, seperti penjumlahan, pengurangan, perkalian, matriks identitas, determinan, dan invers matriks 2×2 , yang menunjukkan lemahnya pemahaman konseptual siswa. Penelitian ini menggunakan pendekatan deskriptif kualitatif dengan subjek sebanyak 27 siswa. Teknik pengumpulan data meliputi tes tertulis, wawancara, dan dokumentasi. Analisis data dilakukan menggunakan model Miles dan Huberman, yaitu reduksi data, penyajian data, dan penarikan kesimpulan. Hasil tes tertulis dianalisis berdasarkan indikator kesulitan dan diperdalam melalui wawancara dengan siswa yang memperoleh nilai rendah. Hasil penelitian menunjukkan bahwa kesulitan memahami konsep merupakan kesulitan paling dominan dengan persentase 51,8%, ditandai oleh kesalahan menentukan ordo matriks, penerapan operasi baris-kolom, serta penggunaan rumus determinan dan invers. Kesalahan menarik kesimpulan sebesar 33,3%, sedangkan kesulitan penggunaan simbol dan memahami soal masing-masing sebesar 29,6%. Kesulitan tersebut disebabkan oleh lemahnya konsep dasar, kurangnya ketelitian, minimnya latihan, serta kesulitan menafsirkan soal cerita. Penelitian ini menyimpulkan bahwa pembelajaran operasi matriks perlu menerapkan pendekatan berpusat pada siswa, penggunaan media visual, latihan bertahap, dan bimbingan yang menekankan ketepatan prosedural.

Kata kunci: Kesulitan Siswa; Operasi Matriks; Pemahaman Konsep

INTRODUCTION

Education is a conscious and planned process that aims to create a learning and teaching atmosphere so that students can develop their potential optimally, both in terms of spiritual aspects, self-control, personality, intelligence, morals, and skills needed in life in society, the nation, and the state (Borean et al, 2024). In the education system, the process of teaching and learning is two interrelated and inseparable concepts. Learning is understood as a process of changing behaviour, knowledge, and skills acquired through experience, while teaching is a systematic effort to facilitate students to be able to build understanding and concepts independently. Thus, the success of education is largely determined by the quality of the learning process that takes place in the classroom and the active involvement of students in that process.

One field of study that plays a strategic role in education is mathematics. According to Hulu & Siswanti (2024), mathematics is an integral part of education because it contributes to developing logical, systematic, and analytical thinking skills. Mathematics is taught at every level of education, from elementary school to university. Mathematics learning is mandatory at all levels of education. Mathematics exists not only as an abstract science but also as a tool for understanding and solving problems in everyday life (Caprioara, 2015). Therefore, mastery of mathematical concepts is an important indicator in achieving national education goals.

Despite this, mathematics remains a difficult subject for most students. Many students exhibit negative attitudes toward mathematics, characterized by low interest, anxiety, and a tendency to avoid learning mathematics. This condition impacts student learning outcomes (Wen & Dubé, 2022). However, mathematics is not only related to counting activities but also a symbolic language used to solve problems, study patterns, and understand relationships between concepts (Santos-Trigo, 2024). Mathematics plays a crucial role in helping individuals think rationally and solve real-life problems. Therefore, a poor understanding of mathematics can hinder students' ability to master advanced material and apply mathematical concepts contextually (Manfreda Kolar & Hodnik, 2021).

One of the mathematics topics in senior high school that often causes difficulties is matrices, particularly matrix operations taught in grade XI in the odd semester. Matrix material involves presenting data in rows and columns and mathematical operations such as addition, subtraction, multiplication, determinants, and inverses. Based on the results of a study by Zannurra et al. (2023), students experience difficulties in four main aspects of matrix learning: conceptual understanding, operations, application of principles, and mastery of basic facts. Similarly, Siregar et al. (2021) revealed that 63.64% of students experience difficulties in understanding matrix concepts due to weak mastery of prerequisite material, such as operations with integers, fractions, and the use of positive and negative signs. Frequent errors include inaccurate determination of matrix order, inappropriate use of symbols, and procedural errors in matrix multiplication operations (Gagniuc, 2024).

Difficulties in understanding matrix operations are not only influenced by the complexity of the material, but also by internal and external factors of the students. Wahab et al. (2024) stated that students' difficulties are seen in the inability to understand the instructions for the problem, choose the right formula, and determine systematic solution steps. In addition, Sitepu et al. (2022) grouped difficulties in learning matrices into three categories: difficulty understanding the problem, transforming the problem into mathematical form, and carrying out the calculation process. Based on initial observations at MAN 4 Aceh Besar through observations of the learning process and interviews with grade XI mathematics teachers, information was obtained that students still often make errors in determining the order of the matrix, applying the rules of operations, using matrix symbols and notations, and drawing conclusions, especially in story-based problems. This condition has an impact on low student learning outcomes in the matrix material. Therefore, research is needed that examines

in depth the forms and causes of student difficulties in solving matrix operations problems as a basis for improving the mathematics learning process in grade XI.

METHOD

This study used a qualitative descriptive approach to gain an in-depth understanding of nature and causes students' difficulties in solving mathematics problems on matrix operations. The qualitative approach was chosen because it can describe learning phenomena contextually and naturally based on real-world conditions (Sugiyono, 2021). The study was conducted at MAN 4 Aceh Besar, with class XI MIA 2 students as the target and subject of the study. The location was selected based on data availability, school readiness, and the relevance of the teaching materials to the research focus. The study lasted for approximately one month during the current academic year, covering the preparation, implementation, and data analysis stages. This study does not aim to generalize, but rather to understand in depth the characteristics of student difficulties in the context of matrix operations learning at the Madrasah Aliyah level.

The research procedure begins with the planning stage, which includes determining the research focus, developing instruments, and validating them. The research instruments consisted of a written descriptive test, interview guides, and documentation, with the researcher as the primary instrument (Sugiyono, 2021). Data collection techniques included a written test to identify student errors, in-depth interviews with six students with the lowest scores to explore their thinking processes and the causes of difficulties, and documentation as supporting data. Data validity was maintained through technical triangulation, which involves comparing test results, interviews, and documentation to ensure the data obtained is more valid and accountable (Wahyuningsih, 2020). Data analysis techniques in this research refer to the Miles and Huberman interactive model, which includes data reduction, data presentation, and conclusion drawing (Agusta, 2023). Data reduction was carried out by grouping student error types, presenting data in the form of descriptions and tables of findings, and drawing conclusions based on difficulty patterns and causal factors. This selection of methods and techniques was deemed appropriate because it produced rich, in-depth data that aligned with the objectives of qualitative research (Creswell & Poth, 2021).

RESULTS AND DISCUSSION

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The data collection process in this study was carried out systematically and initially began with observation and preliminary interviews with the mathematics teacher of class XI MIA2 to obtain a general overview of the difficulties experienced by students in the matrix operation material. After that, the researcher administered a written test to 27 students as the main instrument to identify the forms of difficulties that arise in solving matrix operation problems, such as difficulty understanding concepts, errors in the use of symbols, difficulty understanding problems, and errors in concluding. During the test, the researcher was accompanied by the subject teacher and gave students 60 minutes to complete five essay questions.

After the test results were analyzed, the researchers selected several students who demonstrated the highest level of difficulty for further interviews. These interviews aimed to explore the causes of difficulties in terms of conceptual understanding, thinking strategies, and influencing internal and external factors. Furthermore, documentation was conducted to strengthen the research data in the form of student worksheets, activity photos, and field notes. All collected data were then analyzed using qualitative analysis techniques to produce a comprehensive picture of the forms and factors causing students' difficulties in solving matrix operations problems. Based on the analysis of 27 student answer sheets, various types of difficulties emerged in learning matrix operations, particularly related to conceptual understanding, symbol use, problem understanding, and accuracy in concluding. In general, students showed variation in material mastery; some students were able to solve problems correctly, while others still made errors of various types. These errors provide an overview of learning areas that require more intensive attention to improve students' understanding of the material.

The written test used in this study was designed to measure the extent to which students experience difficulties in solving matrix operations problems. This instrument was administered to 27 students of grade XI MIA2 MAN 4 Aceh Besar to identify the types of difficulties experienced by students, both in aspects of conceptual understanding, use of symbols and notation, ability to understand problems, and accuracy in concluding. The results of this test serve as a basis for identifying student weaknesses and providing direction for improving learning strategies in the classroom. The first step in the analysis is to group the students' answers based on the type of error or difficulty they encountered. Researchers read and assessed each answer sheet to identify consistent patterns of difficulty. Based on observations and Febriannie & Kurniati (2021), student difficulties can be classified into four main categories:

Difficulty understanding the question

$$\textcircled{5} \quad A = \begin{bmatrix} 2 & -1 \\ 4 & 3 \end{bmatrix} \quad \rightarrow A \times I_2 = A \text{ dan } (2 \times A)$$

$$A = \begin{bmatrix} 2 & -1 \\ 4 & 3 \end{bmatrix} \quad I_2 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 2 \cdot 1 + (-1) \cdot 0 \\ 4 \cdot 1 + 3 \cdot 1 \end{bmatrix}$$

$$= \begin{bmatrix} 2 + 0 \\ 4 + 3 \end{bmatrix}$$

$$= \begin{bmatrix} 2 \\ 7 \end{bmatrix}$$

Figure 1. Type of Work Student Difficulty Understanding the Question

Based on the students' answers in the first figure, it appears that they do not yet fully understand the basic concepts of matrix operations (Lukač, 2025). This is demonstrated by errors in determining the initial steps of the problem-solving process, such as inaccurately identifying the correct operation and errors in grouping matrix elements (Kenney & Ntow, 2024). Students tend to perform calculations immediately without understanding the rules or concepts underlying these matrix operations (Matzakos et al., 2023). This indicates a weak conceptual understanding, which impacts the overall problem-solving process.

Misuse of symbols

The image shows handwritten work on lined paper. At the top, a student has written: $3. A. \begin{bmatrix} 2 & -1 \\ 4 & 3 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$. Below this, they have written: $= \begin{bmatrix} 2-0 & -1-0 \\ 4+0 & 0+3 \end{bmatrix}$. Then, they have written: $= \begin{bmatrix} 2 & -1 \\ 4 & 3 \end{bmatrix}$. At the bottom, they have written: $3.2 \times A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 2 & -1 \\ 4 & 3 \end{bmatrix} = \begin{bmatrix} 2-0 & -1-0 \\ 4+0 & 0+3 \end{bmatrix} = \begin{bmatrix} 2 & -1 \\ 4 & 3 \end{bmatrix}$. There are red boxes around the $-1-0$ and $0+3$ terms in the final step.

Figure 2. Type of Work Student has Misused Symbols

In the second image, the student made an error in using matrix symbols, such as parentheses, matrix notation, and operation symbols (Chamidah & Emanuel, 2025). This error resulted in the written matrix not conforming to correct writing rules. Furthermore, the student also misrepresented the matrix elements and the results of the operations, resulting in an incorrect final answer (Hidayanti, 2020). This error in using symbols indicates that the student is unfamiliar with or does not yet understand the meaning of mathematical symbols in the context of matrix operations (Chin & Pierce, 2019).

Difficulty understanding the question

The image shows handwritten work on lined paper. At the top, a student has written: $4. B. \begin{bmatrix} 10 & 16 & 5 \\ 20 & 16 & 8 \\ 15 & 20 & 16 \end{bmatrix} \begin{bmatrix} 2.000.00 \\ 3.000.00 \\ 1.000.00 \end{bmatrix}$. Below this, they have written: $= \begin{bmatrix} 10 + 2.000.00 & 10 + 3.000.00 & 5 + 1.000.00 \\ 20 + 2.000.00 & 16 + 3.000.00 & 8 + 1.000.00 \\ 15 + 2.000.00 & 20 + 3.000.00 & 10 + 1.000.00 \end{bmatrix}$. Then, they have written: $\begin{bmatrix} 12 & 13 & 6 \\ 22 & 18 & 9 \\ 17 & 23 & 11 \end{bmatrix}$.

Figure 3. Type of Work Student Difficulty Understanding the Question

Figure 3 shows that students are having difficulty understanding the problem's intent. This is evident in the solution steps that do not align with the problem's instructions, such as incorrectly determining what is known and what is being asked (Guaman-Quintanilla et al., 2023). Students appear to be copying data from the problem without processing the information properly. This difficulty in understanding the problem leads students to choose the wrong solution procedure, even though their calculations are partially correct (Barana et al., 2022).

Errors in drawing conclusions

The image shows a student's handwritten work on a math problem. At the top, they define matrix A as $\begin{bmatrix} 3 & 1 \\ 2 & 2 \end{bmatrix}$ and matrix B as $\begin{bmatrix} 5000 & 1000 \\ 1000 & 1000 \end{bmatrix}$. They then calculate $A \times B$ as $\begin{bmatrix} 3 & 1 \\ 2 & 2 \end{bmatrix} \times \begin{bmatrix} 5000 & 1000 \\ 1000 & 1000 \end{bmatrix} = \begin{bmatrix} 15000 & 4000 \\ 20000 & 3000 \end{bmatrix}$. To the right, they write 'Jawab: Perulangan yg dilakukan' and calculate $A \times B = 15.000 + 1000 = 16.000$ and $T \times B = 10.000 + 1000 = 11.000$. At the bottom, they write '25/10' and a circled '80'.

Figure 4. Type of Work Student Errors in Making Conclusions

In the fourth figure, the student has performed several calculation steps, but made an error in concluding. This error is evident in the final answer, which does not align with the previous calculation results or does not answer the question posed in the problem. The student has not been able to connect the calculation results to the overall context of the problem (Rakhmawati & Mustadi, 2022). This indicates that the student is still weak in interpreting the results and organizing them into a correct conclusion (Cullinane et al., 2024).

Based on the analysis of students' answers, four types of difficulties were found in solving matrix operations problems: difficulty understanding the concept, errors in symbol usage, difficulty understanding the problem, and errors in concluding. Difficulty understanding the concept is evident from students' inaccuracy in determining the solution steps according to the rules of matrix operations (Maharaj & Ntuli, 2022). Errors in symbol usage are indicated by inconsistencies in the writing of notation and the arrangement of matrix elements (Blostein & Grbavec, 1997). Furthermore, students also had trouble understanding the problem, resulting in the solution procedure not being used in accordance with the problem instructions (Hardiansyah et al., 2024). Errors in concluding occur when students are unable to relate the calculation results to the context of the problem (Domondon, 2025). These four difficulties are interrelated and indicate that weak conceptual understanding is the main factor causing students' difficulties. The research results are presented in the form of a systematic table diagram of all the difficulties as follows:

Systematic Diagram Table of All Students' Difficulties

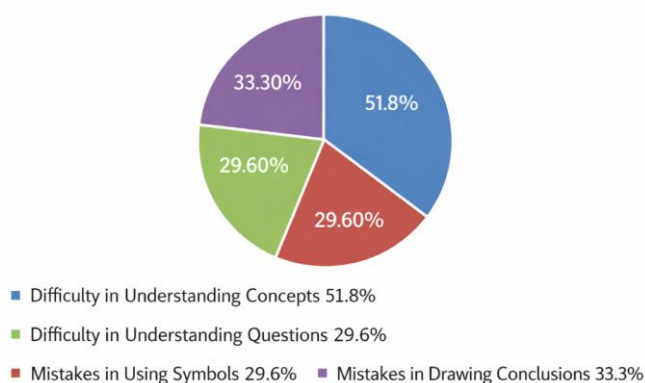


Figure 5. Percentage Distribution of Students' Learning Difficulties

The results of this study focused on the difficulties experienced by class XI MIA 2 students of MAN 4 Aceh Besar in solving matrix operations problems. This study identified four main categories of difficulties: difficulty understanding concepts, errors in using symbols, difficulties understanding

questions, and errors in concluding (Faradiba & Nasir, 2024). It was found that difficulty understanding concepts was the most dominant category, accounting for 51.8%. This indicates that students' basic understanding of matrix operations, such as addition and multiplication, is still weak.

Furthermore, the analysis showed that errors in the use of symbols and notation reached 29.6%. Many students experienced confusion in writing mathematical symbols and understanding basic notation related to matrices. These errors directly impacted their ability to solve problems correctly. Students were often unable to distinguish between identity symbols and other forms, indicating inaccuracy and errors in the use of notation (Veloo et al., 2015). Difficulty understanding problems was also found in the same percentage, namely 29.6%. Students often rushed through reading problems so they could not identify the important information needed to solve the problem. Some students missed the steps of converting information from words to matrix form, ultimately leading to errors in solving (Sitepu et al., 2022). This underscores the need to improve mathematical literacy skills among students.

When it comes to concluding, 33.3% of students experience difficulties. Students who can perform calculations well often draw inaccurate or irrelevant conclusions. These errors arise from a lack of understanding of the relationship between the calculated data and the required result. For example, students can calculate determinants correctly but are unable to interpret the results (Wahyuningsih, 2020). Analysis also shows a relationship between these four categories of difficulties. Students who are weak in understanding concepts often make errors in the use of symbols, have difficulty understanding problems, and are often ineffective in concluding (Woo & Falloon, 2022). A good mastery of basic concepts is crucial to reducing errors that occur at various stages of problem solving (Siregar et al., 2021). Based on observations and interviews with six students, they all agreed that conceptual understanding was their main challenge. Difficulty understanding basic matrix rules, particularly in the context of multiplication and inverses, was a frequent issue (Alam & Mohanty, 2024). Students' grades reflected their inability to apply more complex concepts without a solid foundational understanding (Zannurain et al., 2023).

In conclusion, this study demonstrates the importance of a learning approach focused on strengthening understanding of fundamental concepts (Kintoko et al., 2025; Nathalia et al., 2025). Teachers need to create varied teaching methods and provide more contextual practice questions to help students understand and apply the concept of matrix operations (Liang et al., 2025). By implementing strategic improvements in teaching, it is hoped that student learning outcomes can be improved and current difficulties can be overcome.

CONCLUSION

Based on the results of the study conducted on students of class XI MIA 2 MAN 4 Aceh Besar regarding difficulties in solving matrix operation problems, it can be concluded that students still encounter various obstacles in understanding and applying basic matrix concepts. The findings reveal four main categories of difficulties: difficulty in understanding concepts (51.8%), misuse of symbols and notation (29.6%), difficulty in understanding questions (29.6%), and errors in concluding (33.3%). Conceptual misunderstanding appears as the most dominant issue, reflected in errors in determining matrix order, misinterpreting operational requirements, and incorrectly applying row and column rules. In addition, students demonstrate weaknesses in using formal mathematical notation, interpreting problem statements—particularly story-based questions—and formulating accurate conclusions from their calculations. The overall analysis of written tests, interviews, and documentation indicates that these difficulties are interrelated, as inadequate conceptual understanding tends to trigger symbolic errors, misinterpretation of problems, and inaccurate conclusions. Thus, students' difficulties in matrix

operations stem not only from limited mathematical knowledge but also from insufficient procedural understanding, mathematical literacy, and carefulness.

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