



ANALYSIS OF STUDENT ERRORS IN SOLVING MATRIX PROBLEMS IN CLASS XI OF SMK MUHAMMADIYAH DELANGGU

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ABSTRACT

This study sought to describe mistakes made by SMK Muhammadiyah Delanggu's grade XI students with high, medium, and low abilities when solving matrix problems. It also sought to describe mistakes made by SMK Muhammadiyah Delanggu's grade XI students with concepts, principles, and procedures. This exploration is an engaging subjective examination. The instrument utilized a composed test that included two things, four framework material test questions and meetings were utilized as extra instruments. 14 XI students who had studied matrix material served as the study's subjects. By gathering information from giving composed test questions, understudy mistakes can be distinguished. According to the findings of this study, students of high ability understood the concepts and principles, but performed mathematical operations incorrectly; students of medium ability made procedural errors due to a lack of accuracy in matrix multiplication calculations; and students of low ability made numerous concept, principle, and procedure errors.

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1. INTRODUCTION

Mathematics is a basic science that helps to know other sciences (Yantoro et al., 2021). One of the important concepts in mathematics is the matrix, which has wide applications in various fields such as computer science, engineering, economics, and natural sciences (Howard, A., 2013). Even though the matrix is a basic concept, students often have difficulty understanding and solving problems related to the matrix. Therefore, error analysis

in solving matrix problems is important to help educators and students understand which parts they need to improve understanding.

Through a good educational process will produce quality seeds and increase students' understanding. students can expand their knowledge, abilities, and creativity towards the progress of science and technology through formal education. Learning mathematics is one of the things that is done to increase ability and creativity. Learning mathematics is done to become better at solving problems. The following explains why it is so important to acquire mathematical skills so that you can use them to solve problems in everyday life. The term "able" comes from the concept of power, capacity, and ability (Poerwadarminta, 2005). (Uno, 2008) notes that "a person's ability to work refers to his effectiveness at work, which is reflected in his thoughts, attitudes and behavior." But on the other hand, mathematics compared to other subjects is considered a challenging and even frightening science for students.

According to Newman (Fausan, Sagita, G., 2019), student errors in mathematics usually belong to five groups: understanding errors, awareness errors, change errors, and ability errors, notation errors are listed in that order. According to (Wulandari & Resta, 2018), there are four types of errors students might make when completing numerical statements: theoretical errors, guideline errors, functional errors, and sloppy errors. Students' lack of conceptual understanding of the material they have learned, their inability to understand the language of mathematics, the application of incorrect mathematical formulas, and their thoroughness are the main reasons for errors (Badaruddin, Kadir, & Anggo, 2016).

According to (Ardiawan, 2018), errors are systematic deviations from the correct answer. Error analysis is an attempt to identify, find, and categorize errors according to established principles. Argues that it is necessary to examine student errors in order to identify the various mistakes students make. The type and location of the error can be identified through this analysis, so that the teacher can provide the appropriate answer to ensure that the error can be overcome and does not occur again (Yuni Astuty & Wijayanti, 2013). Information about mistakes made when answering math problems can also be used to help learn math. One of the mistakes that students often make is that it is still difficult to understand the meaning of the questions, especially in matrix material.

The matrix is a sub-material in mathematics. The field of matrix theory covers a wide range of topics, including terms used in matrices, matrix shapes, matrix transposition, matrix similarity, and operations on matrices such as addition, subtraction, multiplication, and inverse operations as well as solving systems of linear equations and matrix equations with matrices and determinants. It is known that certain students perform poorly on the matrix material based on the results of daily tests from the previous year. This is because there are still many students who make mistakes when solving problems involving matrix material, especially when calculating matrix operations, applying matrix concepts, matrix determinants, and matrix equations.

The researcher focused on analyzing the descriptions of students' errors in solving matrix problems with variations in students' mathematical abilities, especially the ability of individual students as measured by the mathematical ability test scores, because the researcher wanted to describe how the description of the errors of students with high, medium, and low mathematical abilities in completing a problems related to matrix.

2. METHOD

This research is included in the descriptive qualitative research which aims to describe students' mistakes in solving matrix material questions. This study focused on 14 class XI students of Muhammadiyah Delanggu Vocational School who had received matrix

material. Classes are taken from the suggestions of subject teachers at school. The instruments given were a two-question ability test and a four-question math test. The instrument was examined by two supervisors and it was stated that the test instrument was valid. The test given to all students in one of class XI at the Delanggu Muhammadiyah Vocational School aims to trace errors in concepts, principles, and procedures that students carry out. While interviews were conducted with selected respondents with different levels of ability with the aim of exploring and clarifying student answers in depth.

3. RESULTS AND DISCUSSION

3.1. Results

According to the results of the four description questions, the students tried to answer correctly even though there were some mistakes. In general, the results of student work when answering the questions presented showed that some students still remembered and understood the matrix material, while other students did not remember how to do the matrix questions. The results of the mathematics ability test which were taken by students of class XI at SMK Muhammadiyah Delanggu were shown for Table 1.

Table 1. Class XI Students' Mathematical Ability Test Results

No.	Name Initials	Mathematical Ability Test Results		
		High	Medium	Low
1	ASA	100		
2	SDAA			45
3	MAPW	80		
4	NNH		75	
5	MRD		60	
6	ASDR			40
7	SKB		70	
8	SY			50
9	AYR	100		
10	YDTE			45
11	NLM			45
12	MNF			40
13	IL		75	
14	PAN			40

The researcher divided the students into several categories based on the test results above and their math ability scores. Three categories including high, medium, and low abilities are used to categorize students. After that, as stated in **Table 2** following are the students who were selected as research subjects.

Table 2. Research subject

Students' Mathematical Ability	Student Initials	Average
High	MAPW	93
Medium	SKB	70
Low	SY	43

Each research subject was given a math test which contained four questions about matrix material according to the categorized table results. The test distributed has met the validity requirements of the expert. Concept, principle, and procedure errors are several types of errors found in the test results given to each group of students. **Table 3** below shows a recapitulation of the different types of errors.

Table 3. Types of High Ability Student Errors

Student	Problem 1			Problem 2			Problem 3			Problem 4		
	Co	Pr	Pr	Co	Pr	Pr	Co	Pr	Pr	Co	Pr	Pr
	√	√	-	√	√	√	√	√	√	√	√	√

MAPW

Problem number 1 discusses matrix transpose, matrix operations, and multiplication of two matrices. Table of Error Test Results as shown by the student above, the subject had no difficulty in solving the problem about transpose matrix in problem 1. However, the student made a mistake in calculating the matrix operation. The results of student work show that students are able to record answers based on concepts and principles, but are not careful in calculating mathematical operations. Figure 1 shows the results of student work.

Table 4. Types of Medium Ability Student Errors

Student	Problem 1			Problem 2			Problem 3			Problem 4		
	Con	Pri	Pro	Con	Pri	Pro	Con	Pri	Pro	Con	Pri	Pro
	√	√	-	√	-	-	√	√	√	√	√	√

SKB

Problem number 2 discusses the multiplication of two matrices and matrix operations. From the Table of Student Error Test Results above, it is clear that students do not understand how to answer questions involving matrix operations in question 2. Students find it difficult to work on questions regarding principles and procedures.

Table 5. Types of Low Ability Student Errors

Student	Problem 1			Problem 2			Problem 3			Problem 4		
	Con	Pr	Pr	Con	Pr	Pr	Con	Pr	Pr	Con	Pr	Pr
	√	√	-	√	√	-	-	-	-	√	-	-

SY

Questions 3 and 4 discuss the operation of multiplying two matrices, matrix determinants, and matrix inverses of the order 2x2 and 3x3. The table of Student Error Test Results shows that the individual experienced difficulties when solving matrix problems. Students have difficulty when trying to solve questions that require an understanding of concepts, principles and procedures in questions 3 and 4.

The following is an excerpt from the conversation between the researcher and students with high intelligence about problem number 1.

Researcher : Do you understand after reading the question?

MAPW : yes I understand ma'am

Researcher : try to explain the meaning of transpose matrix

- MAPW : transpose matrix is the exchange of positions in a part of the matrix by rows into columns.
- Researcher : but in the search for the value of c you are wrong in the mathematical operation
- MAPW : yes ma'am I was not careful when calculating it

According to the results of interviews between researchers and high-skilled students, it was found that the subject could explain what the transpose matrix means through simple language, but was not careful when doing mathematical calculations. **Figure 1** displays the results of student work.

Handwritten mathematical work for Figure 1. The student defines matrix A as $\begin{bmatrix} 3a & a+2b \\ 3b+2c & -5c-d \\ -e+2d & e-2f \end{bmatrix}$ and matrix B as $\begin{bmatrix} -1 & 1 & 1 \\ 0 & 4 & 3 \end{bmatrix}$. They then calculate $B^T \cdot A$ and set it equal to $\begin{bmatrix} -1 & 0 \\ 1 & 4 \\ 1 & 3 \end{bmatrix}$. This leads to a system of equations: $3a = -1$, $a+2b = -1$, $3b+2c = 3$, $-5c-d = 4$, $-e+2d = 0$, and $e-2f = 0$. The student solves these equations step-by-step, finding $a = -1/3$, $b = -1/3$, $c = 1/3$, $d = 0$, $e = -3$, and $f = 1/2$.

Figure 1. Results of High Ability Students on question number 1

Students prepare assignments using existing principles and concepts, as shown in the image above. But in the search for the value of c , it is wrong to calculate the mathematical operation.

In contrast to high-quality students, students with moderate skills work with a different strategy for question number 2. The results of the answers of moderate-skilled students, for example, are presented Figure 2.

Handwritten mathematical work for Figure 2. The student defines matrix A as $\begin{bmatrix} 2a+2 & b+1 \\ 2a+4 & 2b+2 \end{bmatrix}$ and matrix B as $\begin{bmatrix} 2c & -4 \end{bmatrix}$. They then calculate $P \cdot 2Q = R$ and set it equal to $\begin{bmatrix} 0 & 3 \\ 2 & -1 \end{bmatrix}$. This leads to a system of equations: $2a+4 = 0$, $2a+4 = 2$, $a+2 = 3$, $b+1 = -1$, $2c = 0$, and $-4 = 3$. The student solves these equations step-by-step, finding $a = -2$, $b = -2$, and $c = 3$.

Figure 2. Results of Medium Ability Students for question number 2

The following figure explains if students are not careful in doing multiplication of switches with matrices. The following is an excerpt from the conversation between the researcher and the medium skilled students about question number 2.

- Researcher : Are you sure from preparing question number 2 that you have the correct answer?
- SKB : Not sure ma'am
- Researcher : which part are you not sure?
- SKB : In the multiplication of numbers and matrices, I'm still confused, ma'am
- Researcher : do you know the switch multiplication with the matrix?
- SKB : I don't understand if the sign is different $(-) \times (+)$
- Researcher : OK, I'll study it again, OK, the multiplication of switches and matrices, and be more thorough in doing it
- SKB : Okay ma'am

Low quality student outcomes when tackling matrix problems are explained for Figure 3.

$$3 - A. \text{ nilas } x . P = \begin{bmatrix} 3 & 3 \\ 1 & x \end{bmatrix} = 0$$

$$P = \frac{1}{(3x) - (1.3)} = 0$$

$$\frac{1}{3x - 3} = 0$$

$$1 = 3x - 6$$

$$1 + 6 = 3x$$

$$7 = 3x$$

$$\frac{7}{3} = x$$

Figure 3. Results of Low Ability Students on question number 3

The picture above shows the work of low-ability students who do not understand multiplication formulas and operations in matrix problems. The student does not understand the concepts, principles and procedures in question number 3.

The following is an excerpt from the conversation between the researcher and low-ability students about question number 3.

- Researcher : Do you not understand the meaning of question number 3?
- SY : Yes ma'am I do not really understand
- Researcher : in your opinion, where is the difficulty?
- SY : in the working formula section ma'am and not careful when calculating
- Researcher : here it is true that you are wrong in using the formula and the results are all wrong, please understand the meaning of the problem again and don't be careless anymore when calculating the operation.
- SY : okay ma'am

The image shows handwritten mathematical work on lined paper. It consists of two parts, labeled 'a' and 'b'. Part 'a' shows the calculation of the inverse of matrix A, A^{-1} . The student starts with the formula $A^{-1} = \frac{1}{-4 - (-3)} \begin{bmatrix} 2 & 1 \\ -3 & -2 \end{bmatrix}$. They then simplify the denominator to $-4 - 3$, resulting in $-\frac{1}{7} \begin{bmatrix} 2 & 1 \\ -3 & -2 \end{bmatrix}$. Part 'b' shows the calculation of the inverse of the transpose of matrix B, $(B^T)^{-1}$. The student starts with $(B^T)^{-1} = \frac{1}{4 - (-6)} \begin{bmatrix} 4 & -2 \\ -3 & 1 \end{bmatrix}$. They then simplify the denominator to 10 , resulting in $\frac{1}{10} \begin{bmatrix} 4 & -2 \\ -3 & 1 \end{bmatrix}$.

Figure 4. Results of students with low expertise on question number 4

The picture above shows the results of students with low skills on question number 4. The student was not careful when calculating the addition and subtraction operations.

The following includes excerpts from conversations between researchers and low-skilled students about problem number 4.

Researcher : do you know what is matrix inverse?

SY : I do not know ma'am, but the formula knows

Researcher : ok, here you are right when you enter into the formula but are not careful when calculating the addition and subtraction operations

SY : yes ma'am, I know there is a miscalculation

Researcher : Tomorrow I will be more careful when calculating the addition and subtraction operations

SY : okay ma'am

3.2. Discussion

Based on the written answers of students who have high intelligence for question number one, the following errors were found: This is in accordance with the theory (Wiyartimi, 2010) that there are various types of errors made by students, one of which includes operational errors, especially errors made students when using mathematical operations, this is supported by the persistence of students who are not easy when solving calculation problems. The student is using the concept correctly to determine how to transpose A and B, but is still having difficulty with the counting task. As a result, the student's answer becomes incorrect.

Students with moderate ability levels make mistakes when multiplying scalars by matrices. When multiplying a certain scalar value by each element of the matrix, the sign on the scalar value is not included. This error is caused because the student performs the wrong mathematical procedure. According to (Utami, 2012) arithmetic errors are mistakes made when performing mathematical operations including adding, subtracting, multiplying, and dividing. Students have not seen when answering questions so an error occurs.

According to the results of the answers given by students with low abilities on questions 3 and 4, it is generally assumed that these students made several mistakes, especially errors in understanding the concept of matrix equations and errors in determining the formula, which led to errors in determining the inverse of the transpose matrix B. This is in accordance with research (Wijayanti, 2010) by showing that many students have difficulty

understanding equations. Formulas must be learned and understood by students because just remembering them will not be enough.

4. CONCLUSION

According to the results and previous discussion, the following are conclusions that can be drawn by each group of students.

1. For students with high numerical abilities, it turns out that these subjects have not made mistakes in concepts and principles. It was explained if the students were able to prepare the questions correctly. But the math calculations are still wrong. From the results of the interviews it appears that the subject is able to provide additional explanations through language that is straightforward and easy to understand.
2. For students with medium numerical abilities, they can answer the questions given according to the concepts and principles correctly. However, students made procedural errors because they handled the problem of scalar multiplication with an incomplete matrix.
3. Students with low numerical skills often make mistakes for all three categories. The subject made a conceptual error in determining the formula. Likewise, the subject was not careful in calculating the subtraction operation so that procedural errors occurred.

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