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ANALYSIS OF JUNIOR HIGH SCHOOL STUDENTS' MATHEMATICAL REASONING ABILITY ON TWO VARIABLES LINEAR EQUATION SYSTEM MATERIAL

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ABSTRACT

Mathematical reasoning ability is one of the essential mathematical abilities that students must master well. This research aims to analyze the mathematical reasoning abilities of junior high school students on two variables linear equations system material. The research was conducted at SMP Negeri 69 Bandung involving grade eighth students as research subjects. The samples taken were 21 students. This research uses a qualitative descriptive approach. Data collection was carried out through documentation of test instruments in the form of mathematical reasoning ability tests. The analysis results show that the percentage of student errors varies for each indicator of reasoning ability. In detail, the first and second indicators show a very low error percentage, namely 11% and 27%. However, in the third, fourth, and fifth indicators, the percentage of errors increased significantly, by 67%, 69%, and 56% respectively, which is categorized as moderate and low. The sixth indicator shows the highest percentage of errors, which is 89%, which is in the high category. Overall, the average percentage of student errors is 53.17%, which can generally be categorized as very low. These findings indicate a variation in students' mathematical reasoning abilities in two variables linear equations system material. In addition, this study is also expected to contribute to identifying the types of errors commonly made by students and their implications for improving the mathematics learning process.

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INTRODUCTION

Mathematical reasoning ability is one of the essential mathematical abilities that students must master well (Ariati & Juandi, 2022). This is in line with Kusumawardani et al. (2018) who stated that reasoning plays an important role in mathematics because it serves as the foundation for other process standards. Furthermore, according to Noviyana et al. (2024), reasoning ability makes it easier for students to accept and draw conclusions from information validly and critically.

Indicators of mathematical reasoning ability according to Sumarmo (Lestari & Andinny, 2020) in mathematics learning are as follows: 1) Drawing logical conclusions; 2) Providing explanations with models, facts, properties, and relationships; 3) Estimating answers and solution processes; 4) Using patterns and relationships to analyze mathematical situations; 5) Formulating and examining conjectures; 6) Formulating counterarguments; Following inference rules, checking argument validity; 7) Constructing valid arguments; and 8) Constructing direct, indirect proofs, and using mathematical induction. Based on the Technical Guidelines of the Director General of Basic and Secondary Education, Depdiknas Number 506/C/Kep/PP/2004 (in Nurharyanto, 2023), the indicators of mathematical reasoning ability are detailed as follows: 1) making conjectures; 2) performing mathematical manipulations; 3) drawing conclusions, constructing proofs, providing reasons or evidence for several solutions; 4) drawing conclusions from statements; 5) checking the validity of an argument; and 6) finding patterns or properties of mathematical phenomena to make generalizations.

One of the mathematics topics that often poses a challenge for students is two variables linear equations system material. According to Zulfah (2017), two-variable linear equations are a mandatory subject to be studied and understood in order to easily solve problems related to the two variables linear equations system material, which is studied in grade VIII of junior high school. This is in line with the opinion of Sari and Lestari (2020) who stated that in mathematics, the material that contains problems in students' daily lives is two variables linear equations system material for eighth grade junior high school students in the first semester. Students ability to solve problems in this material reflects the extent to which students are able to think logically, analyze information, and make decisions.

Several previous studies have examined students' difficulties in understanding the concept of systems of linear equations with two variables. According to Rohmah and Mahmudah (2024), there are errors in working on problems of linear equations with two variables, namely procedural errors, technical errors, and conceptual errors. Another study was conducted by Hulu and Siswanti (2024) who stated that students made concept, principle, and operational errors in solving problems of linear equations with two variables. Meanwhile, according to research conducted by Adriansyah et al. (2024), the errors made when students worked on problems of linear equations with two variables were errors at the reading stage, errors at the understanding stage, errors at the transformation stage, errors at the process skill stage, and errors when writing the final answer.

This research aims to conduct an in-depth analysis of the errors made by students when solving problems that measure mathematical reasoning abilities in the material of two-variable linear equations. According to Rahmania and Rahmawati (2016), error analysis is an investigation of a form of deviation or error from students' written answers. This is in line with the opinion of Wea and Saputro (2024) who stated that the difficulties experienced by students in solving problems can be identified through tests to reveal what mistakes students make during the process. In other words, this study aims to contribute to a better understanding of students' difficulties in this material and to identify specific types of errors.

This study employs a qualitative descriptive approach, allowing for an in-depth analysis of the data. According to Sugiyono (Anggraini, 2021), qualitative descriptive research aims to describe or depict existing phenomena, whether they are natural or man-made, and pays more attention to characteristics, quality, and interrelationships among activities. Qualitative research is conducted with the characteristic of describing facts or a real situation, but the report must consider scientific interpretation to produce good results (Fadli, 2021). Additionally, this study focuses on the analysis of errors in each indicator of mathematical reasoning ability, thus providing a more comprehensive picture of students' difficulties.

The results of this study are expected to be a reference for mathematics teachers in designing effective learning to overcome students' difficulties in understanding the concept of systems of linear equations with two variables. In addition, the results of this study can also be the basis for further research that wants to develop better instruments for assessing mathematical reasoning ability.

METHOD

This research is a qualitative descriptive research. The subjects of this research were 21 students in class eight of SMP Negeri 69 Bandung. The data collection techniques used in this research were through student test results on systems of linear equations with two variables and interviews. The instruments used in this research were a mathematical reasoning ability test consisting of six essay questions and an interview guide. The analysis stage was carried out after the data was collected. Data analysis included calculating scores and percentages of achievement in mathematical reasoning ability, grouping data, presenting data, and drawing conclusions.

The steps involved in this research are as follows:

1. Selection of Research Material. The research material, which is the system of linear equations with two variables, was chosen prior to the commencement of the study. This specific topic was selected as the focus of the research.
2. Development of a Mathematical Reasoning Test Instrument. A test consisting of six open-ended questions was developed to measure the students' mathematical reasoning abilities. These questions were designed to assess the students' capacity for logical thinking, problem-solving, and critical evaluation.
3. Test Implementation. The mathematical reasoning ability test was administered to the students after they had completed the unit on systems of linear equations with two variables. This allowed the researcher to assess the impact of the learning experience on the students' reasoning skills.
4. Data Analysis. The test results were analyzed by calculating the percentage of students who achieved each level of mathematical reasoning ability. Additionally, a detailed analysis of the students' errors was conducted to identify common misconceptions and difficulties.
5. Drawing Conclusions. Based on the data analysis and interviews with selected students, conclusions were drawn regarding the overall level of mathematical reasoning among the students and the specific types of errors they made when solving the problems.

To determine the number of errors, the following percentage formula was used:

$$P = \frac{n}{N} \times 100$$

Information:

P = Percentage

n = Number of errors

N = Number of possible errors

Referring to the score conversion, according to Nurkanca and Sunarta (Faelasofi, 2017):

Table 1. The Score Conversion

Percentage	Criteria
$90 \leq Pt \leq 100$	Very High
$80 \leq Pt < 90$	High
$65 \leq Pt < 80$	Currently
$55 \leq Pt < 65$	Low
$Pt < 55$	Very Low

RESULTS AND DISCUSSION

Results

The following is a table of results from the percentage of student scores on each question item.

Table 2. Student Results for Each Question Item

Amount	Question Score						Total Score
	1 (4)	2(4)	3(4)	4(4)	5(4)	6(4)	
Score 21 student	75	61	28	26	37	9	236
True (%)	89%	73%	33%	31%	44%	11%	46,83%
False (%)	11%	27%	67%	69%	56%	89%	53,17%

Table 3. Percentage of Number of Error Answers for Each Indicator

No	Reasoning Ability Indicator	True %	False %	Error Criteria
1	Make allegations	89%	11%	Very low
2	Performing mathematical manipulations	73%	27%	Very low
3	Drawing conclusions, compiling evidence, providing reasons or evidence for the correctness of the solution	33%	67%	Currently
4	Draw conclusions from statements	31%	69%	Currently
5	Checking the validity of an argument	44%	56%	Low
6	Finding patterns or properties of mathematical phenomena to make generalizations	11%	89%	High

Judging from tables 2 and 3, it can be seen that the percentage of errors in students' mathematical reasoning abilities is very low overall. The first indicator of mathematical reasoning ability shows a low error rate with 11% of incorrect answers. Similarly, the second indicator also exhibits a low error rate with 27% of incorrect answers. However, the third and fourth indicators demonstrate moderate error rates with 67% and 69% of incorrect answers, respectively. The fifth indicator shows a low error rate with 56% of incorrect answers, while the sixth indicator exhibits a high error rate with 89% of incorrect answers. Despite these variations across indicators, the overall percentage of incorrect answers given by students was 53.17%, which falls within the very low error category. This suggests that while students may struggle with specific aspects of mathematical reasoning, their overall performance is

commendable. One possible contributing factor to the errors observed in the sixth indicator could be time constraints. Some students may have spent an excessive amount of time on the first question, leaving insufficient time to complete the subsequent questions, particularly the more challenging ones.

The following section provides an analysis of the students' mistakes in solving 6 mathematical reasoning problems on the topic of Systems of Linear Equations in Two Variables:

1) The school holiday season is almost here. One of the tourist attractions in City A, Snow Park, is a man-made snow park that is very popular among people during the holidays. Visitors come not only from within the city but also from outside the city. Ticket prices at Snow Park are divided into two categories: children's tickets and adult tickets. During this holiday, Mr. Agung and his family came to visit Snow Park. For two adult tickets and three children's tickets, Mr. Agung had to pay Rp290,000. In addition to Mr. Agung's family, there were Mr. Bambang's family and Mr. Cholif's family who visited at almost the same time. Mr. Bambang paid Rp260,000 for three adult tickets and one child's ticket. If Mr. Cholif brings Rp500,000, is it enough to buy four adult tickets and three children's tickets? Explain!

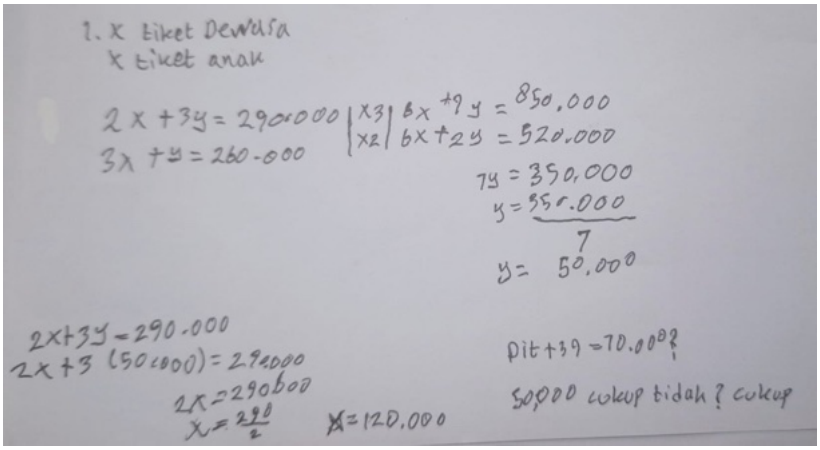

Figure 1. Example of Answer to Question Number 1

In question number 1, the error in making an allegation is in the very low category. Figure 1 illustrates that students primarily erred in determining the value of x and demonstrated a lack of understanding regarding the process of arriving at the final solution to the given problem.

2) Budi and Chiko are playing a number guessing game. They take turns asking and answering questions. Budi asks Chiko the following question: "The sum of two whole numbers is 45 and the difference between the two numbers is 23. What is the product of these two numbers?" How many answers must Chiko state to be correct?

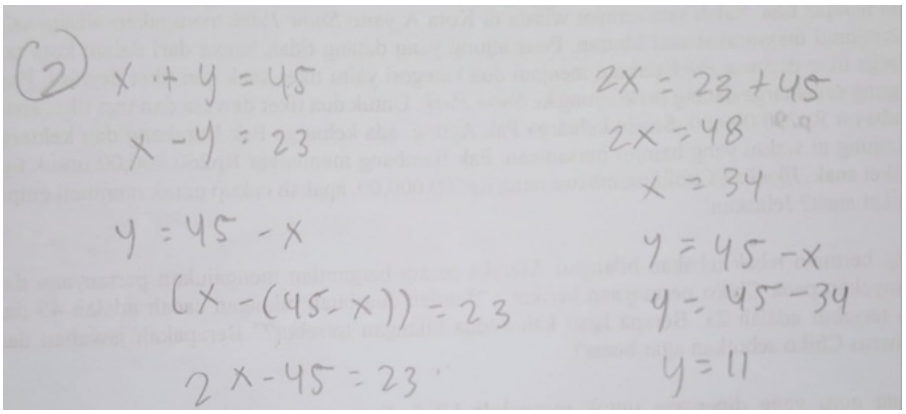

Figure 2. Example of Answer to Question Number 2

In question number 2, the error in carrying out mathematical manipulation was in the very low category. Figure 2 shows that the student was able to perform the necessary mathematical operations, but failed to correctly interpret the meaning and significance of the obtained result within the context of the question.

3) Mrs. Tina is a teacher who is in charge of managing the school health unit (UKS) at her school. Mrs. Tina always prepares some eucalyptus oil in the UKS, both 30 mL and 60 mL sizes. "Jaya" Pharmacy sells both types of eucalyptus oil. The price of 60 mL eucalyptus oil is twice the price of 30 mL eucalyptus oil. To meet the monthly needs of the UKS, Mrs. Tina paid Rp73,500.00 to buy 3 bottles of 30 mL eucalyptus oil and 2 bottles of 60 mL eucalyptus oil. The next day, Mrs. Tina bought eucalyptus oil again at "Jaya" pharmacy because she received additional donations for the UKS from the students' parents. With Rp50,000.00, Mrs. Tina bought two 30 mL eucalyptus oil and one 60 mL eucalyptus oil. The amount of change that Mrs. Tina received was...

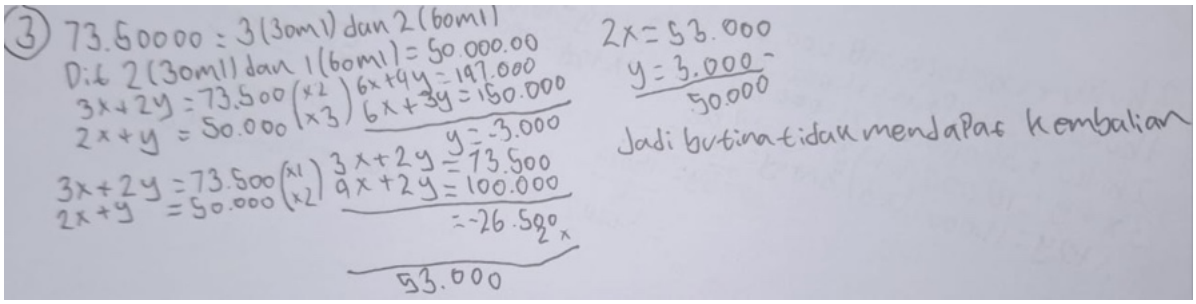

Figure 3. Example of Answer to Question Number 3

In question number 3, errors in drawing conclusions, compiling evidence, and providing reasons or evidence for the correctness of the solution are categorized as moderate. As illustrated in Figure 3, a significant number of students exhibited a lack of meticulousness in their calculations, leading to inaccuracies in evidence preparation and subsequent erroneous conclusions.

4) One day, Mr. Harun bought two types of rice, namely rice A and rice B. The price of rice A was Rp16.000,00/ kilogram, and the price of rice B was Rp18.000,00/kilogram. Mr. Harun wants to buy rice A and rice B with a total weight of 20 kilograms and a total price of Rp334.000,00. How many kilograms of rice A and rice B should Mr. Harun buy?

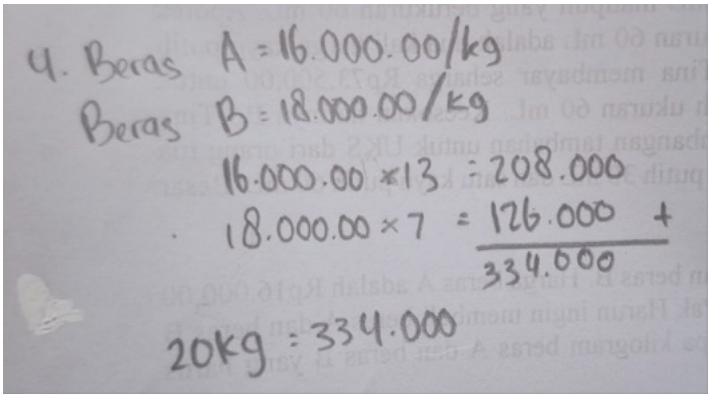

Figure 4. Example of Answer to Question Number 4

In question number 4, the error in drawing conclusions from the statement falls within the medium category. Figure 4 reveals that a significant number of students demonstrate a limited understanding of how to logically manipulate and interpret given statements to arrive at valid conclusions. Instead of employing deductive reasoning or analyzing the relationships between

the presented information, students often resort to guessing possible values to answer the question.

5) A few days before the school holidays ended, Alisa, Bayu, and Cici went to a stationery store. Alisa bought 3 notebooks and 1 ballpoint pen for Rp18.000,00, while Bayu bought 1 notebook and 2 ballpoint pens for Rp11.000,00. That day Cici brought Rp15.000,00 to buy a notebook and a pen. Check whether Cici has enough money to buy 2 notebooks and 3 pens!

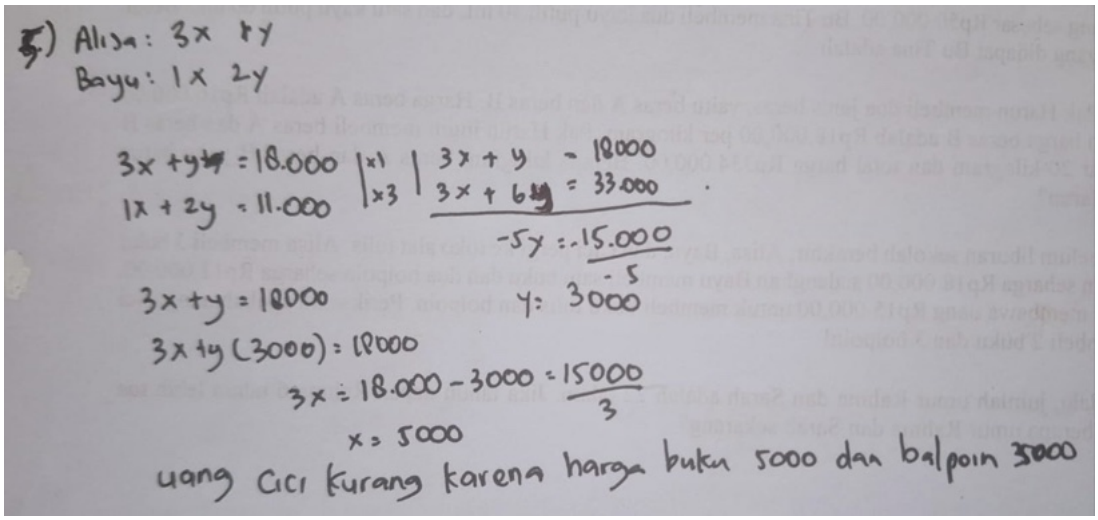

Figure 5. Example of Answer to Question Number 5

In question number 5, errors in checking the validity of an argument are in the low category. Figure 5 shows that while students can perform the initial calculations correctly, they demonstrate a lack of understanding of how to logically assess the implications and conclusions derived from those calculations. They may be able to manipulate the equations and arrive at a solution, but they struggle to interpret the results within the context of the given argument and determine whether the solution is valid and meaningful..

6) One year ago, the sum of Rahma's and Sarah's ages was 22 years. If next year Rahma is 6 years older than Sarah, how old are Rahma and Sarah now?

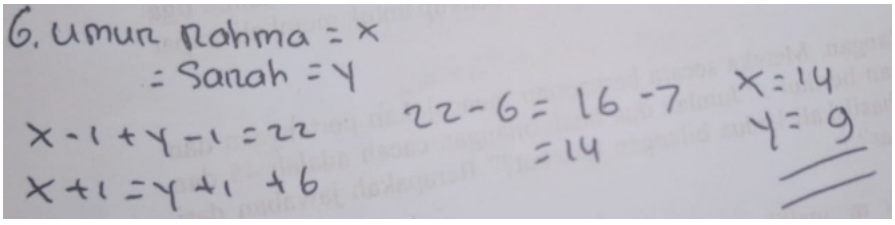

Figure 6. Example of Answer to Question Number 6

In question number 6, the error in finding patterns or properties of mathematical phenomena to make generalizations is in the high category. Figure 6 demonstrates that while students can identify the pattern presented in the question, they struggle to generalize this pattern and apply it to solve the problem, leading to incorrect answers.

Based on interviews with several students, it was found that they did not understand the questions, forgot the formulas, did not know how to solve the problems, and had a poor grasp of the concepts.

Discussions

Based on the field research findings presented in the results, it can be observed that the students' errors were classified as very low. The findings of this research are consistent with several

previous studies regarding the mathematical reasoning abilities of junior high school students in the subject of Systems of Linear Equations in Two Variables. Selvia et al. (2019) stated that the mathematical reasoning ability of junior high school students in the subject of Systems of Linear Equations in Two Variables was in the moderate category due to factors such as students' background of easily giving up on mathematics, being too hasty, and making incorrect operational steps in solving problems. This aligns with Nabila & Marlina (2022), who mentioned that mathematical reasoning ability falling into the low category was more prevalent than students in the high or moderate categories. Furthermore, Yanah & Hakim (2022) indicated that the mathematical reasoning ability of junior high school students was still considered low in solving problems related to Systems of Linear Equations in Two Variables, especially in the indicators of providing reasons for the truth of a solution, drawing logical conclusions, and presenting mathematical statements orally, in writing, or in diagrams. This finding is reinforced by Widyanawati & Firmansyah (2022), who stated that students only achieved two out of six indicators when they speculated and manipulated mathematical data. Lastly, Siahaan et al. (2023) stated that students with low mathematical reasoning abilities had not yet understood the problems well and were unable to mention the known elements, and the students were also unable to plan.

CONCLUSION

Based on data analysis and discussion, the conclusion shows that students' errors in working on mathematical reasoning questions on systems of linear equations with two variables are classified as very low. The percentage of errors made by students for the first indicator is 11% in the very low category, the second indicator is 27% in the very low category, the third indicator is 67% in the medium category, the fourth indicator is 69% in the medium category, the fifth indicator is 56% in the low category, and the sixth indicator is 89% in the high category. Overall, the percentage of errors made by students is 53.17%, so it is in the very low category. Of the six indicators in this research, students made the most mistakes in the sixth indicator, namely finding patterns or properties of mathematical phenomena to make generalizations..

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