

Analysis of Students' Errors in Solving HOTS Problems on Algebraic Materials Based on the Complexity Level of the Problem Based on Bloom's Theory

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Abstract

Mathematics discusses a lot about various kinds of problems that contain numbers that are classified as Higher Order Thinking Skills (HOTS). Math HOTS questions require a high level of thinking to solve the problem. Based on Bloom's theory, HOTS consists of analyzing (C4), evaluating (C5), and creating (C6). This study aims to determine the level of student errors in solving HOTS questions based on Bloom's theory. This research uses mixed method research, which is a combination of qualitative and quantitative methods, where the stages of this research include instrument development, instrument validation, data collection, data analysis and interpretation. The sample of this study used 25 students of class VIII junior high school in Mataram City. Researchers gave 10 essay questions that had been validated by material experts to students as research instruments. The results showed that students' understanding in solving HOTS problems was still lacking. For the error rate, it was found that there were no students who could solve the creating (C6) section with a percentage of 100% error, analyzing (C4) section with a percentage of 60%, evaluating (C5) 24%, applying (C3) 16%, understanding (C2) 12%, and in the remembering (C1) section there were no students who made mistakes with a percentage of 0% error. The biggest error was found in the creating part (C6), where the most mistakes were made by women with an average score of 50.55.

Keywords: HOTS; Student Error; Linear Equation Systems; Bloom Theory

1. Introduction

Math lessons are currently still very unpopular with students. Students think that math lessons are very scary, because they deal with numbers. Even though mathematics is very important and useful in everyday life. Mathematics in algebra material is very much used in life. Mathematical knowledge is also very important in education and needs to be improved. According to [1][2][3][4] education needs to be improved. According to [5] Whether a country advances or not depends on its level of education, because education is a carrier for improving and developing the quality of human resources. One of the steps to improve human resources is to learn mathematics. In learning mathematics, students are trained to think critically, systematically, creatively and logically. In addition according to [6][7] mathematics has a clear and strong structure and relationship between concepts, so that students can be trained to think rationally. Achieving higher order critical thinking skills is a very important goal in education. To realize this goal, the author uses HOTS questions to test the level of students' abilities and errors.

In today's world of education, mathematics is still very uninterested by most people. Math is considered a very confusing lesson. Where in math contains numbers or calculations. Especially

when entering Higher Order Thinking Skills (HOTS) questions. Where when entering HOTS questions we are directed to learn to analyze more deeply a problem contained in the problem [8][9][10]. In writing HOTS questions, the question writer must understand, be able to measure and formulate the material that will become the question. Writing HOTS questions must understand the material that will be used as teaching material, skilled in composing questions (clear question construction).

Bloom's Taxonomy is a framework for thinking, where Bloom's Taxonomy has six levels in the cognitive process, namely: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating [11], Bloom's taxonomy to improve teaching-learning in introduction to programming [12], Taxonomy of educational objectives: The classification of educational goals, by a committee of college and university examiners [13], Bloom ' s Taxonomy Bloom ' s Taxonomy [14]. The first level, namely remembering, is included in the LOTS category (Lower Order Thinking Skills), the next two levels of understanding and application are included in the MOTS category (Middle Order Thinking), and the next three levels are included in the HOTS category (Higher Order Thinking Skills). HOTS is the highest level of cognitive thinking [10], Development of Higher-Order Thinking Skills (HOTS) Questions of Probability Theory Subject Based on Bloom's Taxonomy [15]. Analysis of Student Errors in Solving Hots Problem Based on Mathematical Reasoning Ability [16], Analysis of Student Errors in Solving Hots-type Problems Based on Polya's Procedure on Algebraic Material [17].

The material taken is equations and systems of linear equations of two variables. A two-variable linear equation is the same equality relationship in algebraic form with two variables of rank one. The reason why it is called a linear equation is because it is in the form of an equation if depicted graphically, it will form a straight line graph. Meanwhile, the system of linear equations of two variables is one of the learning materials at the junior high school level. Where the form of the question uses a lot of story problems with HOTS type. Students think to analyze the problem, make mathematical modeling and make variable memorization to solve the problem, which makes many students have difficulty understanding the problem and solving a story-shaped SPLDV problem. So that the scores produced by students are not optimal or very low. Based on the exposure of relevant research, that there is a difference between research that has been conducted by several researchers and research that will be conducted by researchers, namely there is a different subject matter and material, the material used is different, and uses different theories. While the material that will be used by researchers is related to the algebraic material of the Two-Variable Linear Equation System in class VIII with the level of complexity of the problem based on Bloom's theory. Therefore, the researcher will explain what mistakes students make in solving HOTS problems on the material of equations and systems of linear equations of two variables [18][19][20][21][22][23][24]. The findings of this study are also supported by research [25][26][27].

Based on the description above, the researcher will conduct a study entitled analysis of student errors in solving HOTS questions in algebra material in terms of the level of complexity of the problem based on Bloom's theory. This study aims to determine the location of errors made by students in solving HOTS questions on equations and systems of linear equations of two variables based on Bloom's theory.

2. Methods

The type of research used is mixed method research, namely research with a combination of qualitative and quantitative methods, qualitative methods are used when describing and quantitative methods are used for calculations, where the stages of this research include compiling instruments, instrument validation, data collection, data analysis and interpretation. This study aims to provide an in-depth description of the level of errors made by junior high school students in solving story problems based on the level of complexity of Bloom's taxonomy theory and the causes of errors.

The description of the research was carried out by providing an overview of the level of difficulty of HOTS questions based on Bloom's taxonomy. The number of subjects used was 25 8th grade students at one of the middle schools in Mataram city. The data collection technique is by giving essay questions and documentation. The instrument used in this study is by giving 10 essay questions on the material of equations and systems of linear equations of two variables and documenting when conducting research. After collecting data, the researcher analyzes the data then interprets and finally makes conclusions from the data that has been obtained. So it can be concluded that with Bloom's theory can analyze the error rate of description questions. The indicators in levels based on bloom's theory.

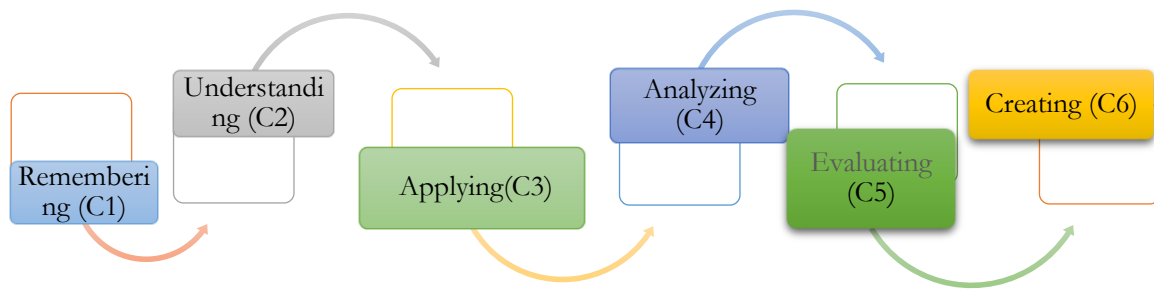


Figure 1. Bloom's Theory Level Indicators

Figure 1 illustrates the levels based on Bloom's theory,

- a. Remembering (C1)
In this section students are directed to try to remember the material previously learned, namely the material of equations and systems of linear equations of two variables.
- b. Understanding (C2)
In this section, students are directed to try to understand the problems given in accordance with the material they have learned.
- c. Applying (C3)
In this section students are directed to apply or apply a two-variable linear equation to a problem that has been given.
- d. Analyzing (C4)
In this section, students are directed to be able to analyze problems and solve problems.
- e. Evaluating (C5)
In this section students are directed to re-evaluate and solve the problems that have been given.
- f. Creating (C6)
In this section, students are directed to try to create a solution that has been given.

Next will be described how the process of compiling the data that has been obtained, from the preparation of instruments to interpretation and conclusions.

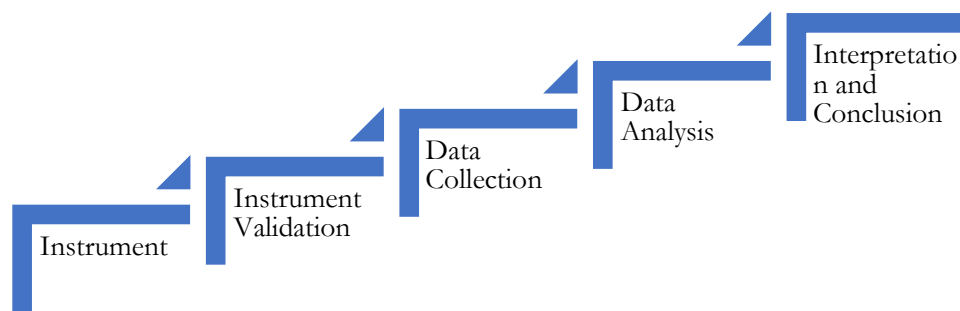


Figure 2. Data Preparation Process

Figure 2 shows the organization of the data compilation process,

- a. **Instrument**
In this section the author compiles an instrument that will be given to students. Where, the instrument used is 10 Essay questions on the material of equations and systems of linear equations of two variables.
- b. **Instrument Validation**
Furthermore, the author validated the instrument that had been made to the material expert.
- c. **Data Collection**
Next, the author carried out the data collection process to the field.
- d. **Data Analysis**
After collecting data, the author analyzes the data that has been obtained by giving question instruments to students.
- e. **Interpretation and Conclusion**
After analyzing all the data, the last thing to do is to interpret and make conclusions from all the data obtained.

3. Result and Discussion

3.1 HOTS Question Validation Results

Before testing to students the questions will be validated first. Question validation has been carried out to material experts. The validation of this question aims to determine whether the question is feasible or not. Based on the results of the validation of HOTS questions that have been carried out to two material experts, namely Mr. Abdillah, M.Pd and Mr. Mahsup, M.Pd, the results are as shown in Table 1.

Table 1. HOTS question validation results

No	Expert	Average	Category	Notes
1.	Material Expert	4,33	Worth	Problem indicator, problem boundary adjustment, problem clarity, problem solving

Based on Table 1, the results of the material expert validation, the questions are declared feasible to be given to students as research instruments. Because the indicators of the questions and the limits of the questions to be given to students are appropriate, the questions are clear enough, and there is already an answer key to the stages of solving the problem.

3.2 Test Results

From the research data that has been done, it is found that there is not one student who can solve the problem in the creation section and there is still a lack of understanding of students in

analyzing the problem. When viewed from the level of student error based on Bloom's theory, students make mistakes in parts C4 and C6. The mistakes made by students make the scores obtained cannot be maximized, it can happen because, lack of understanding of students because they do a lot of online learning during COVID and lack of student accuracy when reading questions. Based on the mistakes that students have made when working on HOTS questions on the material of equations and systems of linear equations of two variables, the complete data can be seen in Table 2,

Table 2. Student Errors Based on Bloom's Theory

NO	Gender	Total Scores	Error indicator
1	Female	57	C5, C6
2	Female	38	C3, C4, C5, C6
3	Female	43	C3, C4, C5, C6
4	Female	52	C5, C6
5	Female	43	C3, C4, C5, C6
6	Female	33	C3, C4, C5, C6
7	Male	59	C6
8	Female	55	C4, C6
9	Male	55	C6
10	Male	40	C5,C6
11	Male	60	C6
12	Female	64	C6
13	Female	57	C4, C6
14	Male	55	C6
15	Male	52	C2, C6
16	Male	53	C6
17	Male	50	C2, C6
18	Female	57	C2, C6
19	Female	57	C6
20	Male	50	C4, C6
21	Male	50	C6
22	Male	52	C5, C6
23	Male	40	C4, C5, C6
24	Male	52	C6
25	Male	52	C6

Based on Table 2, none of the students met the Minimum Completion Criteria (called KKM) score at their school, where the KKM in the school in mathematics is 75. While the average score obtained by all students is 51.04. Where the average female student is 50.55 and the average male student is 51.43. With the highest score of 64 and the lowest score of 33. Based on the data that has been taken, the percentage of student errors is obtained in Table 3.

Table 3. Percentage of Student Errors

Items	Number of Errors	Percentages
C1	0	0%
C2	3	12%
C3	4	16%
C4	15	60%
C5	6	24%
C6	25	100%

Based on Table 3, it can be seen that the most mistakes were made in the creating part (C6) and in the analyzing part (C4). Where in the creating part (C6) students made mistakes with a percentage of 100%, it means that none of the students could solve the problem in the creating part. Then, a fairly high error was made in the analyzing part (C4) in this section students made mistakes with a percentage of 60%, it means that there were 15 students who made mistakes in the analyzing part (C4). However, in the remembering section (C1) all students answered correctly, with a 0% error presentation.

3.3 Problem Error Analysis Based on Bloom's Theory

In this section, the researcher will discuss the mistakes made by students in solving HOTS questions on the material of equations and systems of linear equations of two variables that have been done by students.

a. Remembering Error (C1)

The following will present examples of errors in questions in the remembering section (C1). Here is one of the problems given to students. Look at the following equations!

- (i) $3p + 5q = 10$
- (ii) $2x^2 - 3y = 6$
- (iii) $3y = 5x - 2$
- (iv) $3x + 5 = 2x - 3y$

Figure 3. Student answers in the remembering section (C1)

Figure 3 shows students' answers in the remembering part (C1) students are able to remember how the form of the two-variable linear equation. Where here all students are able to remember how the form of a two-variable linear equation, which results in 0% student errors in solving HOTS questions based on Bloom's theory.

b. Understanding Error (C2)

The following will present the form of error in the understanding part (C2).

Figure 4. Errors in understanding (C2)

Translate Figure 4,

For example

x = pencil price

y = book price

the price of 3 pencils and 5 books is 19.500

Figure 4 illustrates students' answers in the understanding part (C2), students still lack understanding because they do not write the results of converting into the form of two-variable linear equations requested in the problem. Students should write the two-variable linear equation but students do not write what is asked in the problem. Where the two-variable linear equation that students should write is $3x + 5y = 19.500$.

c. Errors in Applying (C3)

The following will present the form of error in the question part of applying (C3).

$$2 \times \text{lebar} = D = \text{panjang} \quad 2p + 2l = 64$$

Figure 5. Errors in Applying (C3)

Translate Figure 5,

$$2 \times \text{width}, D = \text{length} \quad 2p + 2l = 64$$

Figure 5 shows student errors in the applying part (C3), this part students are asked to write the formula for the perimeter of a rectangle that has a perimeter of 64 cm, but in the form of a two-variable linear equation. Students should have written the formula for the perimeter of the rectangle first. Where, the formula for the perimeter of a rectangle is $(2 \times \text{length}) + (2 \times \text{width})$, then write the memorization, with memorization

$$p = \text{length in centimeters}$$

$$l = \text{width in centimeters}$$

with the known perimeter of the rectangle which is 64 cm. Then the linear equation written by the student is correct, namely, $2p + 2l$. However, the way to apply to linear equations is still not understood by students.

d. Analyzing Error (C4)

The following will present the form of question errors in the analyzing section (C4).

$$\begin{array}{r} 2x + y = 12 \\ x - y = 3 \\ \hline 3x = 15 \\ x = \frac{15}{3} \end{array}$$

Figure 6. Errors in analyzing (C4)

Figure 6 shows student errors in the analyzing part (C4), students are still lacking in analyzing the problem. It can be seen from the student's answer in **Figure 6**, that the student did not write the continuation of the answer. The student should write the result of $x = \frac{15}{3} = 5$, so that the x value obtained is 5, then the student should continue by finding the y value of the equation, where because the x value is known then we can find it in the way that has been instructed in the problem, namely by elimination. In the student's answer, the student only eliminates once, namely eliminating y so that only the x value is obtained. Students should have eliminated x again to get the value of y . Here's how to eliminate x to get the y value

$$\begin{array}{r} 2x + y = 12 \quad |x1| \quad 2x + y = 12 \\ x - y = 3 \quad |x2| \quad 2x - 2y = 6 \quad - \\ \hline 3y = 6 \\ y = \frac{6}{3} = 2 \end{array}$$

So the x value is 5 and the value is 2.

e. Error Evaluating (C5)

The following are examples of errors in the evaluation part (C5).

misalkan
 $x = \text{uang parkir mobil}$
 $y = \text{uang parkir motor}$
 ditanyakan $20x + 30y = \dots$

Figure 7. Errors in evaluating (C5)

Translate Figure 7,

Figure 7 shows student errors in the evaluating part (C5), students still lack of re-evaluation of the problems that have been given, on the answer sheet one of the students only wrote the memorization without any answer from the memorization. Students should also write the mathematical modeling and then complete the answer. The mathematical modeling is, $3x + 5y = 17.000$ and $4x + 2y = 18.000$. From the two equations from the mathematical modeling, students should continue to find x and y , which can be done by substitution-elimination. First, we can eliminate x to get the value of y

$$\begin{aligned}
 3x + 5y &= 17.000 \quad | \times 4 | \quad 12x + 20y = 68.000 \\
 4x + 2y &= 18.000 \quad | \times 3 | \quad 12x + 6y = 54.000
 \end{aligned}$$

$$14y = 14.000$$

$$y = \frac{14.000}{14}$$

$$y = 1.000$$

From the y value that has been obtained, students can continue by substituting y into one of the equations in mathematical modeling, namely

$$\begin{aligned}
 3x + 5y &= 17.000 \\
 3x + 5(1.000) &= 17.000 \\
 3x + 5.000 &= 17.000 \\
 3x &= 17.000 - 5.000 \\
 3x &= 12.000 \\
 x &= \frac{12.000}{3} = 4.000
 \end{aligned}$$

Since the x and y values have been found, we can enter them directly into the equation $20x + 30y$, $20(4.000) + 30(1.000) = 80.000 + 30.000 = 110.000$

f. Creation Error (C6)

The following is an example of an error in the creation part of the question (C6).

Figure 8. mistakes in creating (C6)

Figure 8 shows student errors in the creating part (C6), none of the students can solve the problem in the creating part. Supposedly, students are able to solve the part on creating in the problem given. Students do not write the memorization on the answer sheet, students should write the memorization

$$x = \text{goat}$$

$$y = \text{chicken}$$

the number of goat legs is 4 and chicken legs is 2.

In the cage there are 13 goats and chickens, the animal's legs are 32. Then, the question is the number of goats and chickens respectively. Students should have written the math model, namely

$$x + y = 13$$

$$4x + 2y = 32$$

Then, students should eliminate x or y

$$x + y = 13 \quad | \times 4 | \quad 4x + 4y = 52$$

$$4x + 2y = 32 \quad | \times 1 | \quad 4x + 2y = 32$$

$$2y = 20$$

$$y = \frac{20}{2}$$

$$y = 10$$

From eliminating x , the y value is obtained which is 10.

After getting the y value, students can use the substitution method to get the x value. Substitute the y value into one of the equations that have been made in mathematical modeling.

$$x + y = 13$$

$$x + 10 = 13$$

$$x = 13 - 10$$

$$x = 3$$

So, from the two methods, we get $x = 3$ and $y = 10$

In this part of creating (C6), all students made mistakes in this section, with a percentage of errors of 100%. There are no students who are able to solve problems on the indicator of creating on the questions that have been presented.

According to the researcher's observations from the test results that have been given to students, students are less careful in analyzing the problems that have been given. Based on the test results from students who have been studied, students still lack the ability to analyze and create. However, students still remember enough about the form of a two-variable linear equation. Where the most mistakes are made, namely in the creating part (C6), none of the students can solve the problem of creating (C6). This research is in accordance with previous research, namely research from [25], but different from research from [26]. Where the percentage results of creating (C6) from [26] amounted to 48.96%, but the researcher only discussed the indicators of parts C4, C5, and C6 not discussing parts C1, C2, and C3. In the research from [25] in part C6 obtained the same percentage value of 0% but in part C5 also obtained 0% in contrast to the results of research conducted by researchers.

Based on the data obtained, the total number of students who became research subjects was 25 students, of which there were 11 female students and 14 male students. Errors made in the remembering part (C1) were 0% or no one made mistakes. In the understanding part (C2) there were 3 people who made mistakes with a percentage of 12%, where those who made these mistakes were all male. In the applying part (C3) there were 4 students who made mistakes, all of which were female with a percentage of 16%. In the analyzing part (C4) there were 15 students who made mistakes, of which there were 9 male students who made mistakes with a percentage of 36% errors and 6 female students made mistakes with a percentage of 24%, the total percentage in the analyzing part (C4) was 60%. In the evaluating part (C5) there were 6 students who made mistakes, of which there were 4 male students who made mistakes with a percentage of 16% and 2 female students made mistakes with a percentage of 8%, the total percentage in the evaluating part (C5) was 24%. In the creating part (C6) all students made mistakes with an overall percentage of 100%. Based on the average score between women and men, women have a lower average score than men, namely 50.55 while men have an average score of 51.43.

Factors that influence the lack of student accuracy can be caused by students when getting learning equations and systems of linear equations of two variables during the Covid-19 season, where at that time students studied online through their respective homes by utilizing their cell-phones. Thus, students do not maximally understand the learning provided. Based on studies from [28][29][30], another factor for students who are less careful is the lack of parental supervision when children are at home, children always play cell-phones to play online games so that children forget time to study.

4. Conclusion

Based on the level of complexity of the questions from Bloom's theory. The most mistakes were made in the creating part (C6), even all students made mistakes in that section, namely the creating part with a 100% error percentage. Then in the analyzing part (C4), students are still very lacking in analyzing the problem so that many make mistakes in the analyzing part, with the percentage generated from the data of all students who are given the problem, namely 60%. Then, in the evaluating section (C5), some students made mistakes with a percentage of 24%. then in the applying section (C3), students also made mistakes with a percentage of 16%. In the understanding part (C2) students made mistakes with a percentage of 12%. The last is remembering (C1), in this section all students still remember how the form of a linear equation of two variables, so none of the students made mistakes in this section and the percentage of errors was 0%.

Based on the data obtained from the study, to improve students' abilities, teachers must pay more attention to the material that students do not understand because the learning process carried out online is very ineffective. When online learning has been done again recently, it can be used to teach or remind students of learning when online takes place at that time, so that students can better understand the lessons taken. However, because students are accustomed to using cellphones since the online learning process makes students always play cellphones to play games instead of learning. So that when students have entered school as usual, students still like to play cellphones to play online games. Supervising children in learning is not only at school, but at home parents must also limit children from playing cellphones. Because most students today play cellphones to play online games instead of studying. So, to maximize student learning outcomes, the cooperation of a teacher and parents is very important in monitoring the development of students' learning abilities.

This research can be utilized by future writers as a reference for writing research. Therefore, the mistakes found can be a benchmark for correcting future mistakes and can also be used to improve the quality of teaching and learning activities and improve student achievement.

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