Level of Understanding of Basic Linear Algebra Concepts among Seventh Grade Junior High School Students: A Qualitative Descriptive Study

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ABSTRACT

This study aims to evaluate the extent to which seventh-grade junior high school students are able to understand basic concepts in linear algebra. The main reason for conducting this study is that many students still have difficulty understanding algebra material, such as the use of symbols, algebraic operations, and their tendency to memorize the steps of solving problems without really understanding their meaning. The approach used is a qualitative descriptive method involving five students selected at random as respondents. The data collection tool is a written test, consisting of multiple-choice and essay questions, analyzed using concept comprehension indicators. The results show that most students fall into the high to very high understanding category for linear algebra material, although errors were still found due to carelessness, not because they did not understand the concepts. In addition, the analysis revealed that several factors, such as teaching methods, student background, and level of learning motivation, also influenced their understanding. These findings are expected to serve as a reference in designing more relevant and effective mathematics learning strategies.

Keywords: Conceptual Understanding; Linear Algebra; Mathematics Learning.

Introduction

Mathematics learning is a process of building students' understanding of facts, concepts, principles, and skills with the teacher acting as an active guide (Sopamena, 2018). Based on the 2013 Curriculum in Permendikbud No. 36 of 2018 (Culture, 2018), this learning aims to shape individuals who are faithful, creative, innovative, productive, and able to contribute to society. According to (Kamarullah, 2017), early mathematics learning equips students with logical,

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critical, analytical, and systematic thinking skills, as well as teamwork skills. Research also shows that web-based blended learning can improve problem-solving skills (At-Tarbawi, 2023), while the Van Hiele approach is effective in deepening mathematical concept understanding (At-Tarbawi, 2022). One area of mathematics that requires a strong understanding of concepts is algebra.

Algebra is one of the important subjects taught in seventh grade and plays a major role in everyday life. Algebraic concepts are often used, either consciously or unconsciously, in solving various practical problems. However, according to Sari et al. (2023) , the results of algebra learning in schools are still not optimal. In fact, algebra is a very important foundation in mathematics. Understanding algebra helps students master other mathematical concepts. Algebra is taught from elementary school to college. In addition, algebra has a wide range of applications, both in academic fields and in everyday life. Therefore, improving the quality of algebra learning is very necessary. Innovative efforts and contextual approaches are needed to make it easier for students to understand this material (Adhiska et al., 2020). However, in reality, observations show that 7th grade junior high school students still have difficulty understanding basic algebraic concepts.

The results of the observation show that 7th grade junior high school students still have difficulty understanding the basic concepts of algebraic forms. Most of them only memorize the procedures without understanding the meaning of the symbols or operations, and find it difficult to convey their answers logically (Al Jupri & Sispiyati, 2024). Similar difficulties are also experienced by prospective teacher students in relating algebraic concepts to real-world applications (Yuwono & Widyawati, 2022). This condition is the reason for conducting this study because teacher-centered learning does not encourage student independence and exploration (Trianto, 2010). To anticipate this, the study offers exploratory strategies, discussions, and the use of contextual media. These efforts are expected to foster conceptual understanding while training students' mathematical communication. Thus, the novelty of this study lies in the identification of factors that influence students' difficulties in algebra and their implications for learning practices in junior high schools (Mareta & Zulkarnaen, 2024).

Conceptual understanding plays an important role in algebra learning because it determines the meaning of mastery of the material. According to Bloom (1956), understanding is not just about memorization, but also includes the ability to grasp meaning, give examples, and explain again. If students' understanding is still lacking, they tend to simply memorize, making it difficult to apply concepts in different contexts. This is in line with the opinion of Fitri, Agustina, and Septiani (2023), who emphasize that true understanding is demonstrated through the ability to explain, while Susanto (2013) emphasizes that conceptual understanding is an indicator of learning success. The main obstacle that often arises is differences in learning abilities (Rudeffendi, 2006). Therefore, innovative learning strategies are needed so that conceptual understanding can be formed in a more meaningful way (Mareta & Zulkarnaen, 2024).

Based on the previous description, this study focuses on analyzing students' ability to understand the basic concepts of linear algebra. Conceptual

understanding is an important foundation in mathematics learning because it is closely related to logical, critical, and systematic thinking skills. However, in the field, many students still experience difficulties in understanding linear algebra, both in terms of concepts and application. This condition prompted the author to conduct research with the title "Level of Understanding of Basic Linear Algebra Concepts among Seventh Grade Junior High School Students: A Qualitative Descriptive Study". This research is in line with the view that mathematics learning cannot be separated from social, cultural, and religious values that play a role in shaping students' characters (Pratiwi et al., 2025).

Method

This study is a qualitative descriptive study with the aim of analyzing the ability of 7th grade junior high school students in understanding the basic concepts of linear algebra. Data collection was carried out using a written test containing algebra questions and analyzed to determine the level of student understanding, which was classified into high, medium, and low categories. This study also aims to reveal common mistakes often made by students in solving linear algebraic problems. This type of research is relevant because it reflects real conditions in the field without any manipulation of variables, thus providing an objective picture of students' understanding. The findings of this study are expected to serve as a basis for teachers in developing more effective and targeted learning strategies (Sugiyono, 2018).

The subjects in this study consisted of five seventh-grade junior high school students who were selected randomly using random sampling techniques. This technique is a sampling method in which every individual in the population has an equal chance of being selected, thereby minimizing bias and producing a more objective overview. The main instrument in this study was a written test consisting of five multiple-choice questions and three essay questions. Data collection was conducted using descriptive qualitative techniques by assessing each student's answers according to the assessment guidelines, classifying the students' level of understanding into good, fair, and poor categories, and compiling a description of the analysis results to illustrate the general trends and characteristics of the students' answers.

The research data was analyzed descriptively and qualitatively using the Miles and Huberman model. This model consists of three main stages, namely 1) organizing and classifying data by thoroughly analyzing the written test answers of five students (multiple choice and essay) and then grouping them into very high, high, medium, low, and very low levels of understanding to identify patterns of understanding and errors that arise, 2) data presentation, which is the process of displaying the analysis results in the form of narratives and tables so that general trends, student characteristics, and patterns and errors that arise can be seen systematically and easily understood, 3) drawing conclusions and verification, which is the process of interpreting student ability trends, comparing them with mathematics education theory, and verifying the results to obtain a comprehensive and accurate picture.

Results

The data obtained from the students' test results will be analyzed to determine the extent of their understanding of basic algebraic concepts. The analysis process is carried out by matching the students' answers to eight indicators related to algebraic material. Five students participated in this study. To obtain a more systematic picture of the aspects assessed in this study, concept understanding indicators were used. These indicators were compiled with reference to the theory of mathematical concept understanding and adapted to the algebraic forms material taught in the seventh grade of junior high school. Details of the concept understanding indicators can be seen in Table 1 below.

Table 1. Indicators of Understanding Linear Algebraic Concepts.

Conceptual Understanding Aspects	Conceptual Understanding Indicators
Determining variables and coefficients	• Able to identify variables in algebraic forms. • State coefficients accurately.
Simplifying algebraic expressions	• Able to correctly combine similar syllables. • Does not mix similar and dissimilar syllables.
Calculating algebraic expressions (variable substitution)	• Able to substitute variable values into algebraic expressions. • Perform calculations according to the rules of operations.
Performing simplification operations	• Performing algebraic operations (addition, subtraction, multiplication, simple division). • Developing logical steps for solving problems.
Determining the value of algebraic expressions with exponents	• Mastering exponent rules in algebraic form. • Calculating substitution values involving exponents.
Determining the value of algebraic expressions with parentheses	• Use the distributive property correctly. • Rewrite the algebraic form of the simplified result.
Formulating and solving linear equations with one variable	• Able to model contextual problems into linear equations. • Solve linear equations correctly.
Adding similar and dissimilar algebraic expressions	• Perform algebraic addition systematically. • Distinguish between like and unlike terms in addition.

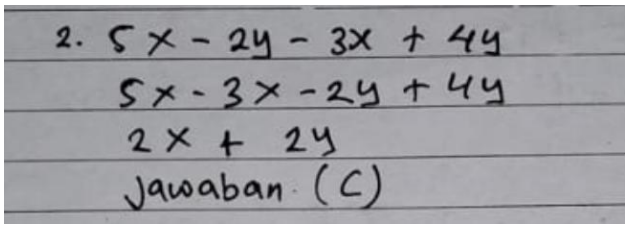
Multiple Choice Question Analysis

Analysis of the five multiple-choice questions shows that most students have a very good understanding of the basic concepts of linear algebraic forms. In question 1, which measures the ability to determine variables and coefficients, all students answered correctly with a percentage of 100%. This shows that students are able to recognize the basic elements in algebraic forms and understand the symbols used. On question number 4, which relates to simplifying algebraic

expressions, all students also scored perfectly. These results indicate that students have mastered basic concepts such as adding and subtracting like terms.

Meanwhile, questions 2 and 3, which focused on simplification and substitution of variable values, each received a score of 80%. The errors that appeared in these two questions were more technical in nature rather than conceptual. Some students made mistakes due to carelessness in choosing answer options, even though their calculations were correct. The following data shows the students' answers for each question item that contained errors:

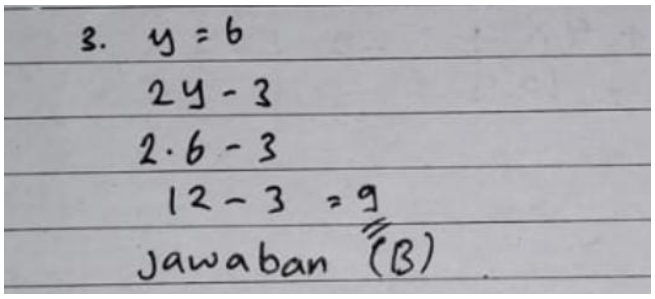
Figure 1. Error in Question 2 (Multiple Choice)



In Figure 1, students are asked to simplify the algebraic expression $5x - 2y - 3x + 4y$ by combining like terms. Based on the students' work, the calculation process was done correctly, resulting in $2x + 2y$. However, when choosing the final answer, the students marked option C $(2x + y)$ when the correct answer was option D $(2x + 2y)$. This shows that the error did not lie in the understanding of the concept of simplifying algebraic expressions, but rather in carelessness in reading and matching the calculation results with the available answer options. Thus, the student actually understood the concept well, but still needed to be trained in accuracy in the final steps of the solution.

Furthermore, some students had difficulty solving problem number 3. In problem number 3, students were asked to calculate the value of the algebraic expression $2y - 3$ by substituting the value $y = 6$. In their work, students correctly wrote $2(6) - 3 = 12 - 3 = 9$, but chose answer B (-9) instead of answer C (9). The results of students' work who still made mistakes in solving question number 3 are shown in:

Figure 2. Error in Question 3 (Multiple Choice)



As in the previous question, the error in Figure 3 does not stem from a lack of understanding of the concept, but rather from a lack of thoroughness in matching the calculation results with the answer choices. This condition shows that the students' conceptual understanding is quite good, but their careful and thorough reading skills still need to be improved. This indicates that students understand the steps to solve the problem, but are not careful enough in reading

or matching the results with the available choices. In other words, their conceptual abilities are quite good, but they need to improve in terms of accuracy.

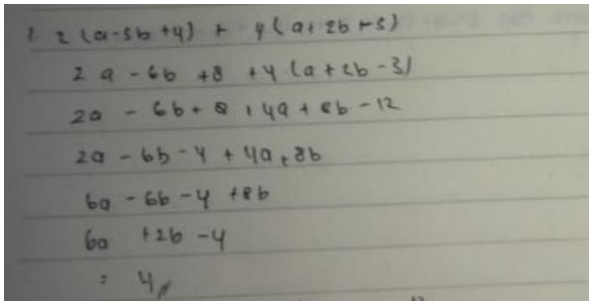
On question number 5, which tested the ability to determine the value of algebraic forms involving exponentiation, the average correct answer also reached 80%. Some students appeared to write down the final answer without showing the steps, making it difficult for researchers to assess their overall understanding of the process. Nevertheless, the majority of students' answers were close to correct, indicating that they had mastered the basic concepts of exponentiation quite well. Overall, the analysis results show that the students' understanding of algebraic expressions was in the high to very high category. Teachers are advised to provide additional exercises that emphasize accuracy and reflection on the calculation process, so that students' conceptual understanding becomes more mature and flexible.

In question number 5, students were asked to determine the value of $p^2 + 2q$ with $p = 2$ and $q = 3$. Based on the work collected, students immediately chose answer B without writing down the steps at all. However, if solved correctly, $2^2 + 2(3) = 4 + 6 = 10$, so the correct answer is C. This error indicates a weakness in the application of systematic solution steps. Although the question is relatively simple, the absence of calculation steps makes it impossible to control small errors in mental calculations. This indicates that students need to be trained to always write down the solution process so that their understanding of algebraic exponents can be applied more carefully and systematically.

Essay Question Analysis

Analysis of the three essay questions shows that, in general, students have a good understanding of the basic concepts of linear algebraic forms, with average scores in the high to very high range. In essay question 1, students were asked to simplify algebraic forms containing parentheses and several variables. Most students were able to correctly arrange the simplification steps and obtain the correct final result, with a success rate of 95%. However, there was one student who only simplified the constant terms without paying attention to the variables, indicating that a small number of students did not fully understand the process of grouping similar terms. This error was a minor conceptual one and indicated the need for additional practice in applying the distributive property to more complex algebraic expressions.

Figure 3. Error in Essay Question 1

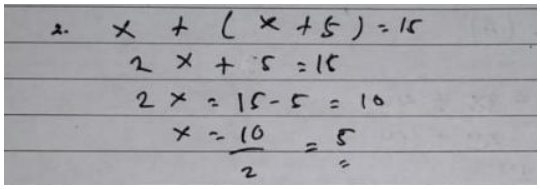


Essay question number 1 asks students to simplify the algebraic expression $2(a - 3b + 4) + 4(a + 2b - 3)$. Ideally, students should group and add like terms

to obtain a simpler form. However, the results show that students only wrote down the final answer 4, which most likely came from simplifying the constant terms only. Students do not seem to pay attention to processing variable terms. This shows that they have not fully mastered the understanding of how to simplify algebraic forms, especially in grouping and adding like terms.

In essay question number 2, students were asked to construct and solve a single variable linear equation based on a contextual problem. The results showed that the majority of students were able to write the mathematical model correctly and find the correct variable value, with an average success rate of 80%. The errors that appeared were more technical in nature, such as copying numbers incorrectly or not reading the instructions carefully. However, the steps used to solve the problem were logical and systematic. These findings indicate that students' symbolic thinking and mathematical modeling skills have developed quite well. However, the aspects of accuracy and consistency in writing down the solution procedure still need to be improved so that their work is more accurate and neat.

Figure 4. Error in Essay Question 2



In essay question number 2, students were asked to construct and solve a single variable linear equation based on the context of the problem. This question required students to write a mathematical model of the statement "the sum of two numbers is x and x + 3. If the sum of the two numbers is 15, determine the value of x." However, in their work, students mistakenly wrote the model as $x + (x + 5) = 15$, resulting in an incorrect final answer. This error was not caused by a lack of understanding of how to solve a linear equation with one variable, but rather by a lack of thoroughness in reading and translating the question into the correct mathematical model. Although the steps to solve the equation were correct, the initial error in modeling caused the final result to be incorrect. This situation shows the importance of thoroughness in understanding and formulating story problems.

Furthermore, on essay question number 3, which required students to add algebraic expressions containing like and unlike terms, all students answered correctly, with a percentage of 100%. This result shows that students understand the concept of grouping and the operation of adding algebraic expressions systematically. This success also indicates that students did not merely memorize procedures, but understood the meaning of the operations performed. Overall, the analysis results show that students have mastered the basic concepts of linear algebraic expressions well. Therefore, teachers are advised to provide open-ended and contextual exercises as well as problem-based learning approaches to deepen conceptual understanding and improve students' critical thinking skills.

With the above grouping of analyses, each question is analyzed sequentially, starting from understanding the question, the results of the students' work, the

types of errors, to the causes and meanings of errors in understanding mathematical concepts. This narrative structure makes the analysis more fluid yet systematic, making it easier for journal readers to understand the different characteristics of errors in each question item.

Discussion

The results of the study show that seventh graders' understanding of basic linear algebraic concepts is high to very high. Most students are able to recognize variables and coefficients, simplify algebraic forms, and perform basic operations correctly. This can be seen from the results of multiple-choice and essay tests, which show a high average number of correct answers on almost all concept understanding indicators. The errors that appeared were mostly not conceptual in nature, but rather technical, such as carelessness in reading questions or matching answers. In addition, the aspect of accuracy in writing down the steps of the work was also a distinguishing factor between perfect answers and answers that were close to correct.

These findings indicate that, conceptually, students have a good understanding of the basics of linear algebra. These findings are in line with Bloom's (1956) theory of conceptual understanding, which states that understanding is demonstrated through the ability to explain and apply concepts appropriately. The results of this study also support the views of Kieran (1992) and Usiskin (1995) that mastery of algebra involves not only symbolic manipulation but also a deep conceptual understanding. Similar research by Mareta and Zulkarnaen (2024) shows that students with a strong conceptual understanding tend to make technical errors rather than conceptual errors. This reinforces the finding that the errors made by students in this study were caused more by carelessness than by a lack of understanding. Thus, good conceptual ability has become an important foundation for students in mastering algebra material.

Based on these findings, it is recommended that further research focus on learning interventions that can improve students' accuracy and consistency in solving problems. The use of innovative learning models such as problem-based learning or contextual learning can be alternatives to strengthen students' critical thinking skills. In addition, further research could involve a larger and more diverse sample size to obtain a more comprehensive picture. Another aspect that could also be studied is the influence of learning motivation and cognitive style on accuracy and precision in solving algebra problems. Thus, future research could contribute more broadly to the development of effective mathematics learning strategies.

Conclusion

The results of the analysis show that seventh graders' understanding of basic linear algebra concepts is relatively high. Most students are able to recognize and perform algebraic operations well, although there are still errors

due to a lack of accuracy. Factors that influence this include teacher-centered learning, minimal exploration, and low motivation to learn. Teachers suggest that learning be made more interactive by involving media or everyday contexts so that students are more interested. Students hope that learning will be conducted in a more enjoyable and easy-to-understand manner, such as through games or group discussions. Researchers suggest the application of innovative learning strategies such as equity-based learning and self-regulated learning to increase motivation and understanding of linear algebra concepts in a more meaningful way (Halim et al., 2025).

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