



## Analysis of the Ability to Understand Mathematical Concepts Based on Student Learning Styles in Calculus Courses

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### **Abstract:**

Understanding mathematical concepts can make a person's understanding of mathematics more complex. However, in reality, students memorize mathematics without developing a strong understanding of the concept. On the other hand, learning style is a student's way of processing the information obtained to build an understanding of mathematical concepts. Based on these two things, this research analyzes students' ability to understand mathematical concepts in solving calculus-related problems by considering learning styles, such as visual, auditory, or kinesthetic. The research method used is descriptive qualitative. The research subjects were students in the first semester of the Informatics Engineering Department at Universitas Islam Lamongan. Data was collected by using questionnaires, tests, and interviews. The research results show that students with auditory, visual, and kinesthetic learning styles are categorized as very good on the indicator of restating concepts, with an average of 84%, 92%, and 81%. Students with an auditory learning style are categorized as very good in presenting examples and non-examples, averaging 72%. Visual and kinesthetic are categorized as good, averaging 64% and 67%. For indicators connecting various concepts, students with auditory and visual learning styles are categorized as poor, with an average of 38% and 36%. In contrast, kinesthetics are categorized as good, with an average of 55%.

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## Introduction

Mathematics lessons exist at every level of education that students must study, even up to college. This is because mathematics is one of the basic sciences that plays an important role in everyday life. After all, the application of mathematics is always used in every human activity, from calculating, buying and selling, profit and loss to social arithmetic, measuring, and so on. This is in line with the opinions of [Chen et al. \(2021\)](#) and [Zulfahrani \(2018\)](#), who state that mathematics functions in developing the ability to calculate, measure, and solve problems. Mathematics is a science that requires students to study specific patterns in which students can then develop their observations about object symbols and coding abstract representations in their knowledge. Based on Kemendikbud Nomor 58 Tahun 2014 concerning the Junior High School (SMP)/ Madrasah Tsanawiyah (MTs) curriculum, one of the objectives of learning mathematics is so that students can understand mathematical concepts, where understanding these concepts is the main goal which is the primary basis for students in solving problems mathematics.

Without the ability to understand this concept, students will experience difficulty in solving every mathematical problem. This is the opinion of [Putri et al. \(2018\)](#) and [Wijaya et al. \(2018\)](#), who stated that in learning mathematics, the intervention provided by teachers is not only limited to memorizing but also provides in-depth understanding so that students are able to understand the basic concepts of the material being studied. If students master the concepts well, they can solve mathematical problems quickly ([Umrana et al, 2019](#); [Radiusman, 2020](#)). This means that a strong and precise understanding of concepts is a bridge to solving mathematical problems. This aligns with the statement from [Novitasari \(2016\)](#) and [Ginting & Sutirna \(2022\)](#) that students who understand mathematical concepts can handle various mathematical problems because they already have a deep understanding of the material.

However, the importance of understanding concepts previously explained differs from the ability to understand concepts students have achieved. The results of research conducted by [Purwaningsih and Rina \(2022\)](#) and [Fajar et al. \(2018\)](#) show that the high category gets a percentage of 15%, the medium category is 65%, and the low category is 20%, so it can be said that students' abilities to understand mathematical concepts vary. The majority are in the sufficient category. Moreover, 87% of students are in the low category; this shows that many students still need help understanding the concept of the problems that have been presented.

During the initial observation conducted by the researcher in one of the Informatics Engineering classes, Semester I, Universitas Islam Lamongan, in learning calculus, which is a branch of mathematics, students generally often have difficulty in solving the calculus problems given, especially if the form of the problem is different from the example problems given by the lecturer. Students generally focus more on remembering or memorizing formulas, resulting in a lack of understanding. The following is an example of a student's wrong answer during the initial observation. Many students gave a different answer to this question.

10.  $\lim_{x \rightarrow 4} f(x)$ , jika  $f(x) = \begin{cases} 2x-5, & \text{jika } x \leq 4 \\ 7-x, & \text{jika } x > 4 \end{cases}$

$\lim_{x \rightarrow 4^-} 2x-5 = 2 \cdot (-4) - 5$   
 $= -8 - 5$   
 $= -13$

$\lim_{x \rightarrow 4^+} 7-x = 7 - (4)$   
 $= 3$

$\therefore$  Karena limit kiri  $\neq$  limit kanan, maka  
 $\lim_{x \rightarrow 4} f(x)$  tidak ada (1)

Figure 1. Example of Student's Wrong Answer During the Initial Observation

Lack of students' understanding of mathematical concepts will have an impact on student learning outcomes and hinder the objectives of mathematics learning (Sari, Sutirna, & Firmansyah, 2023). Based on findings from an interview conducted with a Calculus lecturer at Universitas Islam Lamongan about students' ability to understand mathematical concepts, information was obtained that students still face obstacles in finding solutions to problems of inequality and absolute value, especially when having to adjust to the properties of the inequality itself.

In learning mathematics, each student has unique characteristics in processing information, so each student needs a varied learning style to understand a concept (Khoirunnisa & Soro, 2021; Nurjanah et al., 2022). This indicates that in building mathematical understanding, students have a unique way of learning, which is called a learning style. Learning style refers to learning habits that are more popular with students and can create a sense of comfort in the learning process (Larasati & Widyasari, 2021). This condition can help students obtain information more efficiently and effectively (Larasati & Widyasari, 2021). In other words, the right learning style can help students maximize the process of building their knowledge and gain a better understanding. According to Yohanes and Sutriyono (2018), understanding concepts can be influenced by external factors outside the individual himself (for example, environment, family, etc.) and internal factors. These factors come from the individual himself (for example, intelligence, motivation, learning style, etc.).

DePorter and Hernacki (in Khoirunnisa & Soro, 2021) stated that based on learning modalities, three learning styles are generally known, namely (1) visual learning style, which means students use their sight, (2) auditory, which means students use their hearing; and (3), and kinesthetic, which means students use body movements. This indicates that each person has varied learning tendencies based on their modality preferences for obtaining information and processing various concepts.

Differences in learning styles for each cause the ability to absorb a concept to vary. So, students' levels of understanding of concepts also vary. Some accept it quickly, and some are slow. According to Guswanto et al. (2018), to determine each student's ability to understand aspects of mathematical concepts, learning style is one

of the factors that determines student success. This aligns with [Nurlia et al. \(2021\)](#) and [Usman et al. \(2022\)](#), who state that learning style influences understanding mathematical concepts. Therefore, to provide an in-depth picture, researchers are interested in analyzing the ability to understand mathematical concepts regarding student learning styles.

Compared to previous studies, this study's novelty is that in addition to analyzing students' ability to understand mathematical concepts based on their learning styles, researchers will also analyze which errors in the concept understanding indicators are most often made by students in each learning style.

### Research Method

This research can be categorized as a qualitative descriptive study. The research method uses descriptive data processing ([Djam'an Satori, 2011](#)). This research was carried out in the odd semester of the 2024/2025 academic year at Universitas Islam Lamongan and involved 36 students of 1st-semester class B as research subjects. Using a questionnaire sheet about learning styles given to students showed that 12 students had an auditory learning style, 14 students had a kinesthetic learning style, and ten other students had a visual learning style.

The data collection methods applied include questionnaires, tests, and interviews. This test solves students' mathematical understanding abilities related to accurate number inequalities material by referring to the modifications applied from research by [Yani et al. \(2019\)](#). The test consisted of 3 descriptive questions containing indicators of the ability to understand mathematical concepts, namely (1) restating the concepts that have been studied, (2) presenting examples and non-examples of the concepts that have been studied, and (3) connecting various concepts. Meanwhile, questionnaires are used to identify students' learning preferences and tendencies and categorize them based on their learning styles. Student interviews are used to identify aspects that influence students' mistakes in finding solutions to each question.

The data analysis technique in this research has three steps according to those proposed by Miles and Huberman in [Sugiyono \(2017\)](#), namely (a) data reduction, the researcher carried out data analysis by checking students' answers and conducting interviews in order to obtain information about the stages students went through in finding solutions to the problems given; (b) data presentation, the results of the analysis will be presented in various forms, such as narrative text, images, and tables. In this case, the researcher will present information that has been processed in detail and clearly so that it is easy to understand; (c) conclusion, formulating conclusions from the data reduction and presentation stages. Researchers will carefully evaluate and analyze the collected data to reach objective conclusions. Conclusions are drawn by paying attention to the results of test sheets in solving mathematics problems and interview results to find the characteristics of research subjects based on learning styles—criteria for student learning styles according to ([Mulabiyah et al., 2018](#)) in Table 1.

Table 1. Learning Style Category

Average Score	Category
$71\% \leq A \leq 100\%$	Very Good
$41\% \leq A \leq 70\%$	Good
$0 \leq A \leq 40\%$	Poor

## Results and Discussion

Based on the results of the learning style questionnaire completed by 36 students, the data obtained is shown in Table 2 below:

Table 2. Results of Learning Style Classification

Learning Style	Student Code	Amount
Auditory	IZA, AMK, MIA, NSF, AD, ZMS, OAE, SR, AB, AAS, MAR, MIN	12
Kinesthetic	DCA, FRB, EKS, ADF, RIN, MIA, NER, AF, AWA, EDN, AHM, AKA, ZSF, NFK	14
Visual	ANF, BDS, GAF, MRH, MAG, AB, DSA, MBY, AM, MNC	10

The results of the learning style classification, which can be seen in Table 2, show that the learning style in class 1-B of Informatics Engineering is that 12 students have an auditory learning style, 14 students have a kinesthetic learning style, and ten students have a visual learning style. Thus, students have different learning characteristics in one class.

The analysis results obtained are presented in Table 3, based on students' answers in the mathematical concept understanding test.

Table 3. Percentage of Students Who Answered Correctly

Indicators	Question number	Students Answer Correctly (%)		
		Visual	Auditory	Kinesthetic
Restating the concept	1 (a)	95	91	86
	1 (b)	95	87	83
	1 (c)	86	74	75
<b>Average</b>		<b>92</b>	<b>84</b>	<b>81</b>
Present examples and non-examples	2 (a)	66	77	70
	2 (b)	68	70	63
	2 (c)	58	69	68
<b>Average</b>		<b>64</b>	<b>72</b>	<b>67</b>
Connecting various concepts	3 (a)	40	44	63
	3 (b)	32	32	47
<b>Average</b>		<b>36</b>	<b>38</b>	<b>55</b>

Based on Table 3, the results of student work on question number 1 illustrate that the ability to understand concepts for each student's learning style in restating

concepts is categorized as very good. More than 80% of students were able to solve the questions correctly. Question number 2, describing the ability to understand concepts for students with an auditory learning style in presenting examples and non-examples, is included in the outstanding category; students who answered correctly reached 72%. Meanwhile, students with visual and kinesthetic learning styles are categorized as good at presenting examples and non-examples. Students who gave correct answers reached more than 63%. For question number 3, students with auditory and visual learning styles' ability to connect various concepts still need to be categorized as poor. At most, 40% of students could answer the questions correctly. Meanwhile, for students with a kinesthetic learning style, their ability to connect various concepts is categorized as good. As many as 55% of students could answer the questions given correctly.

### Students with an Auditory Learning Style

Examples of errors that often occur among students with an auditory learning style in completing tests are presented in Figure 2 below.

$$\begin{aligned}
 3a) & 2 - 3x < 5x + 8 \\
 -3x - 5x & < 8 - 2 \\
 -8x & < 6 \\
 x & < -\frac{6}{8} \\
 \text{jadi HP } & \{x \mid x < -\frac{6}{8}\}
 \end{aligned}$$

Figure 2. Student's answer with an auditory learning style for question number 3 (a)

In Figure 2, the student's mistake was not being able to connect concepts. When both sides are divided by a negative number ( $< 0$ ), the inequality sign should change from  $<$  to  $>$ . However, based on the interview results with the student, it turned out that he had forgotten the concept given, so the inequality sign remained, and he got the wrong results.

### Students with a Visual Learning Style

Examples of mistakes that are often made by students with a visual learning style in completing tests are presented in Figure 3 below.

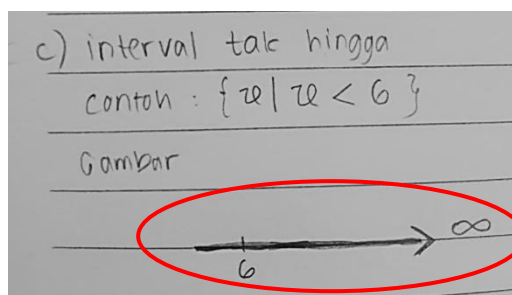


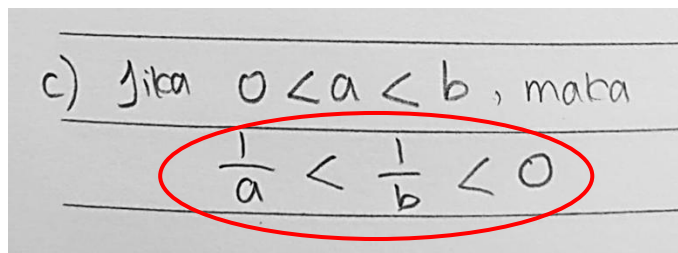


Figure 3. Student's answer with Visual Learning style for Question Number 2 (c)

Figure 3 shows the student's error in the number line drawing. The direction of the arrow should be to the left because 6 is the upper limit of the set. However, the number line drawn is to the right. Based on the interview results, it turned out that the student thought that 6 was the lowest limit. This is because he thinks that if  $x < 6$ , it means the arrow is to the left because it doesn't mean left. After all, it does not mean left. So, this student needs to be able to provide examples and is not an example.

### Students with Kinesthetic Learning Style

Examples of errors that often occur among students with a kinesthetic learning style in completing tests are presented in Figure 4 below.



c) jika  $0 < a < b$ , maka

$$\frac{1}{a} < \frac{1}{b} < 0$$

Figure 4. Student's Answer with Kinesthetic Learning Style for Question Number 1 (c)

In Figure 4, students' mistakes with the kinesthetic learning style are found in the signs of inequality in the final answer results. The correct sign of inequality should be  $>$  but the student's answer was actually. Based on the interview results, it turned out that the student was less able to restate concepts, including the properties of inequality. He can better work on questions with a solution process rather than memorizing them. This is because when solving problems that involve a process, he can use his brain to think. After all, he is writing (his hands are moving).

Based on the results of the analysis presented, students with an auditory learning style often make mistakes when answering questions about combining various concepts. Students' mistakes with a visual learning style often occur in questions about giving examples and non-examples. Meanwhile, students with a kinesthetic learning style often encounter questions about restating concepts.

Students' mistakes with auditory, visual, and kinesthetic learning styles are almost the same. Students still need to understand the instructions for the questions and the concepts that will be applied. Some students still need to be more cautious when working on the questions. If you look at the students' answers, they memorize the formula and then apply it to the questions without understanding the meaning of the formula. In line with what has been expressed by [Setianingrum and Novitasari \(2015\)](#) and [Jusniani \(2018\)](#), students tend to listen to the explanations from lecturers and memorize them without really understanding the meaning of the material given.

### Conclusion

Based on the analysis of understanding mathematical concepts, it was found that students with auditory, visual, and kinesthetic learning styles were categorized as very good on the indicator of restating concepts. In the indicator of presenting examples and non-examples, students with an auditory learning style are categorized as very good, while visual and kinesthetic are categorized as good. For indicators connecting various concepts, students with auditory and visual learning styles are categorized as poor, while students with kinesthetic learning styles are categorized as good. Based on the results of student interviews, students with an auditory learning style often make mistakes when answering questions about combining various concepts. Students' mistakes with a visual learning style often occur in questions about giving examples and non-examples. Meanwhile, students with a kinesthetic learning style often encounter questions about restating concepts.

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