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# The Student's Learning Obstacle in Calculus Course

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**Abstract.** Calculus courses have become the basis of other mathematics courses. However, students often find obstacles in this course that cause low mastery of calculus.Therefore we need an in-depth analysis of students' obstacles in learning calculus to develop proper learning materials and methods. This research aims to analyze the students' learning obstacles in solving mathematical problems in calculus courses. This research is a qualitative descriptive study. The subjects of this study were first-semester students of the Mathematics Department at one of the Islamic institutes in Jambi, Indonesia. The subject selection technique used is purposive sampling, while the data collection techniques used questionnaires and interviews. Based on data analysis, it was found that there were five types of errors made by students in solving mathematical problems in a calculus course, namely conceptual errors, algorithm errors, calculation errors, algebraic operations errors, and careless errors. Also, there were two types of learning obstacles experienced by students in the calculus course: epistemological obstacles and didactic obstacles. Epistemological obstacles related to conceptual errors, limited understanding of concepts, and errors in analyzing questions. While didactic obstacles related to difficulties in understanding teaching materials and inaccuracy of teaching methods. Further research is needed to overcome learning obstacles that occur in the form of developing appropriate learning materials according to the abilities and characteristics of students and applying appropriate learning models and methods.

**Keywords**: Calculus Course; Learning Obstacle; Mathematics Students; Students' Errors

**Abstrak.** Mata kuliah kalkulus menjadi dasar mata kuliah matematika lainnya. Namun, mahasiswa sering menemukan kendala dalam mata kuliah ini yang menyebabkan rendahnya penguasaan mahasiswa pada kalkulus. Oleh karena itu diperlukan analisis yang mendalam mengenai kendala siswa dalam mempelajari kalkulus, untuk mengembangkan bahan dan metode pembelajaran yang tepat. Penelitian ini bertujuan untuk menganalisis hambatan belajar siswa dalam menyelesaikan masalah matematika pada mata kuliah kalkulus. Penelitian ini merupakan penelitian deskriptif kualitatif. Subyek penelitian ini adalah mahasiswa semester satu Jurusan Matematika di salah satu Institut Agama Islam di Jambi, Indonesia. Teknik pemilihan subjek yang digunakan adalah teknik purposive sampling sedangkan teknik pengumpulan data menggunakan angket dan wawancara. Berdasarkan analisis data, ditemukan bahwa terdapat lima jenis kesalahan yang dilakukan mahasiswa dalam menyelesaikan masalah matematika pada mata kuliah kalkulus, yaitu kesalahan konseptual, kesalahan algoritma, kesalahan perhitungan, kesalahan operasi aljabar, dan kesalahan ceroboh. Selain itu, terdapat dua jenis kendala belajar yang dialami mahasiswa pada mata kuliah kalkulus, yaitu kendala epistemologis terkait kesalahan konsep, keterbatasan pemahaman konsep, dan kesalahan menganalisis soal, dan kendala didaktik terkait kesulitan memahami bahan ajar dan ketidaktepatan metode pembelajaran. Diperlukan penelitian lebih lanjut untuk mengatasi kendala belajar yang terjadi berupa pengembangan bahan ajar yang sesuai dengan kemampuan dan karakteristik siswa serta penerapan model dan metode pembelajaran yang tepat.

**Kata kunci**: Hambatan Belajar; Kalkulus; Kesalahan Mahasiswa; Mahasiswa Matematika



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## INTRODUCTION

Calculus is a compulsory subject that mathematics education students must take. The calculus course forms the basis for other mathematics courses, such as advanced calculus and differential equations. In general, calculus is the study of change. Calculus is applied to mathematics, physics, economics, medicine, and others and is used to solve various everyday problems (Dewi & Arini, 2018). So it can be said that calculus is one of the most central materials to be studied, especially in mathematics. Given the importance of learning calculus, students must understand the concepts in calculus courses to make it easier to understand other related materials, such as materials in advanced calculus courses, differential equations, or even apply these concepts in various scientific fields. Therefore the learning process in calculus courses must be designed and implemented with appropriate methods, approaches, and teaching materials.

Based on the value of calculus courses from the last two years in the Mathematics Department at one of the Islamic institutes in Jambi, it can be said that the achievement of lecture goals is less than optimal. This fact can be caused by several factors from within students and external factors. One of the factors among students is the lack of interest in the lecture process. According to Harsono (2005), one of the characteristics of current students is that they are less interested in the lecture process, so their knowledge is limited. In addition, there are also external factors in the form of the influence of using inappropriate methods and approaches as well as teaching materials.

For that, we need an appropriate learning design process in the form of methods and approaches as well as teaching materials to realize learning objectives. According to Vygotsky (Septianti & Afiani, 2020), before designing learning, lecturers must understand the condition of students well so that the lesson plans prepared are by the target because students have varied learning abilities. Teaching materials prepared by lecturers should consider the diversity of student responses to didactic situations that are expected to arise.

In practice, in the natural learning process, students often experience obstacles or obstacles. This situation is called a learning obstacle. According to Brousseau (2002), there are three types of learning obstacles experienced by students in the learning process, namely ontogenic obstacles, didactical obstacles, and epistemological obstacles. Ontogenic obstacles are learning obstacles caused by restrictions on knowledge or concepts experienced by students during self-development related to mental readiness to learn. Didactic obstacles are learning obstacles that occur due to teacher errors in designing the learning process and its implementation. Epistemological obstacles are those experienced by someone with a limited context of knowledge or concepts.

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Yuspriati et al. (2019) also found three types of learning obstacles, namely epistemological obstacle, didactic obstacle, and ontogenic obstacle. It is also found by Fadillah et al. (2019) that students are often reversed in working on integrals and differentials. This fact shows that students have a limited understanding of the concept of integral and differential. It is a learning obstacle that is included in the epistemological obstacle. This study focuses on integral at the high school level and only focuses on learning difficulties or obstacles (Learning Obstacles), not examining errors that arise due to difficulties or obstacles.

Learning obstacles by students in lectures can result in errors in solving problems, such as in working on problems. In his research, many types of errors often occur when working on problems such as Amir (2017) stated that the types of student errors include conceptual errors, principle errors, and operating errors. Meanwhile, Rahmat Basuki (Pujilestari, 2018) revealed that student errors in solving questions consisted of conceptual, operational, and careless errors. Therefore we need an in-depth analysis of the obstacles experienced by students in learning calculus to develop learning to achieve the learning objectives that have been set. This study aims to analyze the errors made by students in solving mathematical problems and student learning obstacles in the calculus course.

## METHOD

This research is a qualitative descriptive study to describe students' errors and their learning obstacles in calculus courses. The subjects of this study were 27 first-semester students of the Mathematics Department at one Islamic Institute in Jambi, Indonesia, chosen using the purposive sampling technique. All of the subjects were contracted calculus courses.

Data collection techniques in this study were tests, questionnaires, and interviews. The test is a descriptive test to obtain information about student errors in solving mathematical problems and learning obstacles in calculus courses. The test questions consist of 5 essay questions on the subject: limits, high-level derivatives, flat area, the volume of solid objects, and numerical integration. The test was validated before by three experts. The results of expert judgment generally show that the questionnaires made are valid and suitable for use in research, but there are some improvements to the sentence structure so as not to cause double interpretation. The test questions used are shown in Figure 1.

While the questionnaire used contains statements to determine the types of learning obstacles that occur in students in the calculus course. The questionnaire used consisted of 17 statements consisting of 4 aspects that were measured. The aspects measured are learning difficulties (difficulty in understanding the material, errors in determining the right formula, and errors in performing calculations), epistemological obstacles (obstacles related to conceptual errors, limited

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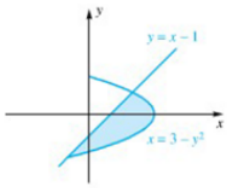
understanding of concepts, and errors in analyzing questions), ontogeny obstacles (obstacle related to mental readiness to learn and obstacle related to prerequisite materials), and didactic obstacle (obstacle related to teaching materials and obstacle related to teaching methods).

1. Find $\lim_{x\to -3} \frac{x^2-14x-51}{x^2-4x-21}$
2. If $y = \frac{3x}{1-x}$. Find $d^3y/dx^3$
3. Approximate the definite integral $\int_1^3 \frac{1}{x^3}\, dx$ using right riemann sum and parabolic rule
4. Find the area of the following shaded area




5. Sketch the region R bounded by $y = x^3 + 1, x = 0, x = 2$ dan $y = 0$ and find the volume of the solid formed when the area is rotated around the axis $x = 4$

Figure 1. Calculus Course Test to Determine Students' Learning Obstacles

The interview used was semi-structured using interview guidelines. Interviews were conducted to clarify data on student learning obstacles. Six students who had to learn obstacles were selected to be interviewed. The data analysis used in this research is data reduction, data presentation, and making a conclusion. To account for the credibility of this research, the researcher triangulated sources, such as test results, questionnaires, and interviews, and interviewed more than one subject.

## RESULTS AND DISCUSSION

### The Student's Error in Solving Mathematical Problems

The types of errors students make in solving mathematical problems in calculus courses consist of conceptual, calculation, algorithm, operating, and careless errors. The conceptual errors are mistakes made by students when students do not understand the concept of the material being taught. The conceptual errors found were in the form of conceptual errors in calculating the volume of solid objects. Several methods are used to calculate the volume of solid objects, including the disc method, the cylinder shell method, and the ring method. In each of these methods, there are different techniques for solving problems. Due to students do not understand the concept of calculating the volume of solid objects, they cannot answer the questions correctly. This is in line with the results of research by Imswatama (2016) on analyzing student errors in solving analytical geometry problems in the line and circle material field. Concept understanding is fundamental in learning mathematics to avoid conceptual errors (Syamsi, 2014).

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Calculation errors are errors made by students when students use appropriate operations but make mistakes when entering numbers. The calculation error is shown in Figure 2.

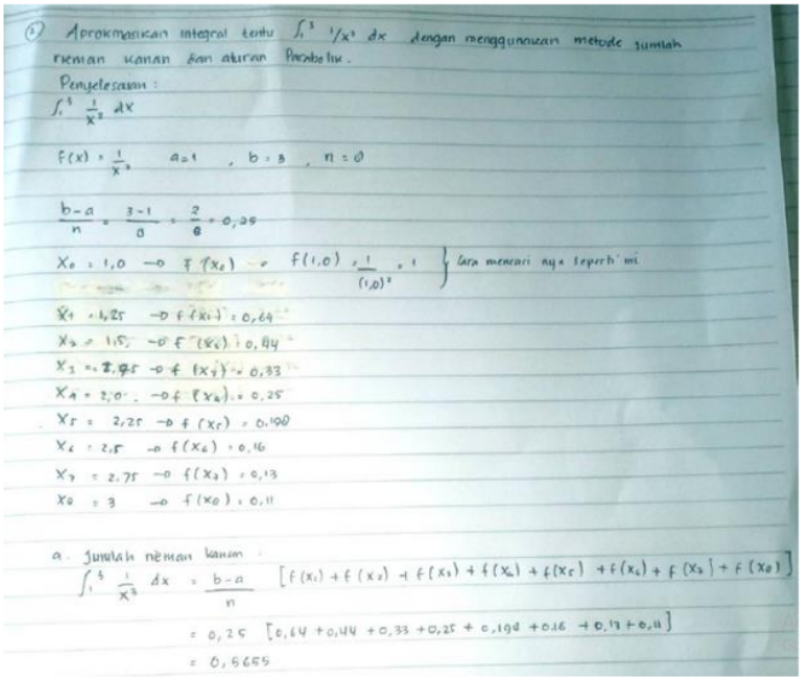


Figure 2. Student Answer Sheet on Calculation Errors

Based on the answers, it can be seen that students understand the concept of approximation using the proper Riemann sum method. In addition, the strategy or formula used is also correct. However, there is an error in calculating the value of *f(x)*. It causes the results obtained to be wrong. The errors made by these students are categorized as calculation errors or numerical computation errors, namely, students using the appropriate operations but making mistakes when entering numbers. One of the causes of calculation errors is when students are not careful in calculating and entering numbers into the formula (Pertiwi, 2016).

Students make algorithm errors when they choose the wrong strategy to solve the problem. The steps taken by students are not following the correct working procedure. Algorithm errors found in this study were in the form of errors in determining strategies for solving problems, such as strategies for determining the area of the flat area between two curves. There are several strategies used, such as horizontal and vertical slicing. In addition, algorithm errors were also found in calculating the volume of solid objects. Some students use the wrong method in solving problems. According to Evianti et al. (2019), algorithm errors consist of errors in writing the conclusion, miscalculating the results of mathematical operations, and errors in the work process, which include the regularity or sequence of steps in completion. Algorithm errors are non-

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hierarchical steps' inability to manipulate steps to solve problems (Sofianingsih & Kusmanto, 2018).

Operational errors are errors made by students in performing algebraic operations or arithmetic operations. Students are said to have made errors in operations if students have been able to transform questions but do not know the procedures needed to do operations correctly and accurately (Cahyani & Sutriyono, 2018). The Algebra operating error is shown in Figure 3. Based on the answer sheet in Figure 3, it can be seen that the students did wrong algebraic operations when describing $(1-2x+x^2)$. The steps taken by students are to use algebra with the translation technique $(a+b)^2$so that the results obtained are wrong. An error like this is called an algebraic operation error.

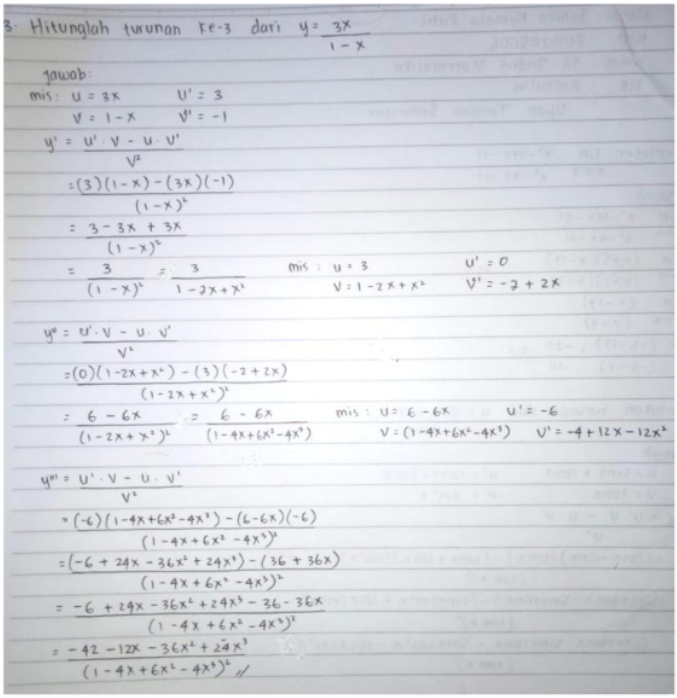


Figure 3. Student Answer Sheet on Algebra Operating Errors

Careless errors are mistakes made because of negligence, even though the student understands the concept and how to solve it. The careless error is shown in Figure 4. Based on the answer sheet in Figure 4, it can be seen that students understand the concept of limit and know how to solve it. The student has taken the proper steps to find the limit value, but there is an error when dividing -20 by -10 equals 10, which should be worth 2. The student knows or understands division and subtraction, but the mistakes made are caused by carelessness and carelessness. Errors like this

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are called careless mistakes. Students are said to make careless mistakes when solving math problems. Students forget concepts, formulas, or operations to be performed (Cahyani & Sutriyono, 2018).

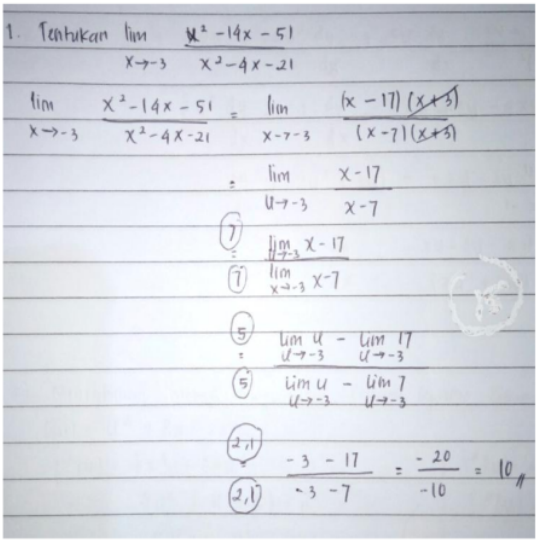


Figure 4. Student Answer Sheet on Careless Errors

According to Sahriah (2013), mistakes made by students can be used as consideration for teaching to improve teaching and learning activities, an increase in teaching and learning activities is expected to improve learning outcomes or student achievement. Errors in solving problems are closely related to learning difficulties. According to Limardani et al. (2015), a person's learning difficulties allow errors to occur in solving problems on certain materials. In other words, when someone makes a mistake in solving a problem, that person likely has learning difficulties. The same thing was expressed by Farida (2015), to find out a person's learning difficulties can be done by looking at the mistakes made in solving the problems.

## The Student's Learning Obstacle in Calculus Course

Students' learning obstacles in the calculus course were obtained from the analysis of the results of students' answers to the questions, as well as analysis of questionnaires and interviews conducted. The data analysis found that the obstacle to student learning in the calculus course consisted of an epistemological and didactic obstacle, while on ontogeny, there were no obstacles.

## Epistemological Obstacle

Epistemological obstacles occur to a person when that person has a limited context of knowledge or concepts. In other words, the person's knowledge is limited to specific contexts, and the

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knowledge possessed cannot be used when faced with different contexts. So that person will have difficulty. In other words, this obstacle occurs when a person does not have a good understanding of concepts, misconceptions, or misconceptions. In this study, the epistemological obstacle was analyzed based on conceptual error, limited understanding of the concept, and errors in analyzing questions. According to Duroux (in Suryadi, 2010), epistemological obstacles are also caused by the fact that during the learning process, students are only given a limited context of knowledge or concepts, so students are not accustomed to solving new problems. Epistemological obstacles are related to conceptual errors, limited understanding of concepts, and errors in analyzing questions.

*Epistemological Obstacle to Conceptual Mistakes*

One type of epistemological obstacle is the obstacle related to misconceptions. This obstacle occurs when students find understanding the concept challenging, so an error occurs when given a mathematical problem. Epistemological obstacles related to conceptual errors are shown in Figure 5.

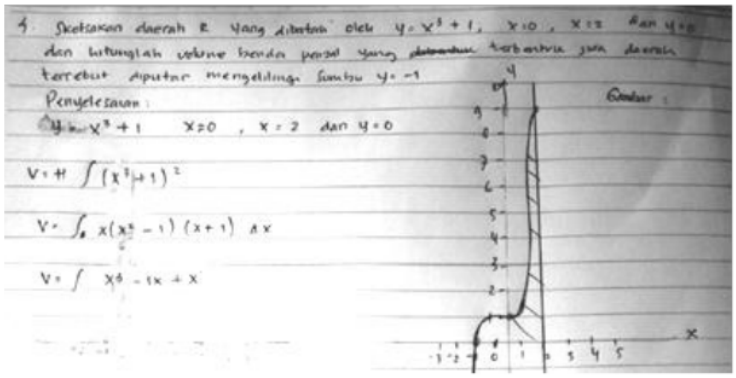


Figure 5. Student Answer Sheet on Epistemological Obstacle Related to Conceptual Errors

Based on the answers, it can be seen that the student does not understand the concept of calculating the volume of a solid object formed if the available area is rotated around the y = -1. The student solved the problem from the picture by integrating the known y function. It shows that he does not understand the concept of calculating the volume of a solid. The ring method should be used to calculate the volume in question. Thus, it can be said that the mistakes made by students are conceptual errors. This can also be seen from the results of the questionnaire analysis given. An average of 2.5 is obtained, categorized as having moderate obstacles. Based on several statements in the questionnaire regarding conceptual errors, it was found that some students answered that they could understand the concept well, while some were still having difficulties. The results of the interviews reinforce it.

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Based on the results of interviews, it is known that students understand that an integration technique is needed to solve the problem, but these students do not understand the concept of calculating the volume of a solid object. It causes students to have difficulty when working on these questions. Thus it can be said that students experience epistemological obstacles related to conceptual errors.

*Epistemological Obstacle Related to Limited Concept Understanding*

In addition to conceptual errors, there is an epistemological obstacle related to limited concept understanding. This obstacle occurs when students already understand the concept, but students have difficulty when given a slightly different problem or question. Epistemological obstacles related to limited understanding of concepts are shown in Figure 6.

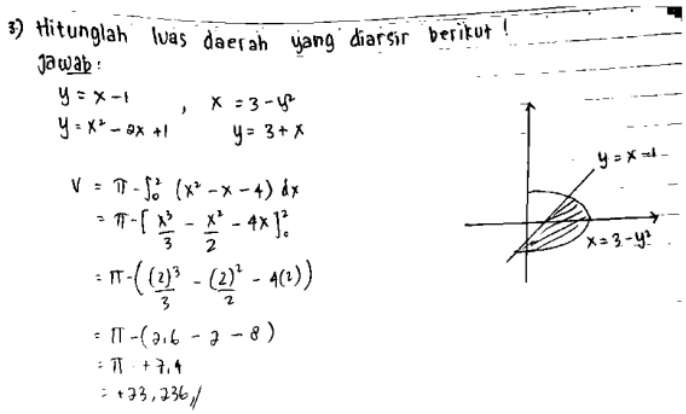


Figure 6. Student Answer Sheet on Epistemological Obstacle Related to Limited Concept Understanding

Based on these answers, it can be seen that the student understands the concept of using integrals to determine the area of the average plane between two curves. It can be seen from the steps taken by using the formula $A = \int_a^b (f(x) - g(x))\, dx$. However, the student had difficulty determining the strategy to use. From the answers, it could be seen that the slicing was done vertically. The slicing should be done horizontally by using y as the integration variable. Students have a limited understanding of concepts related to determining the average area between two curves. Thus, it can be said that there is an epistemological obstacle related to the limited understanding of the concept. This can also be seen from the analysis of the questionnaire analysis. An average of 3.5 is obtained, categorized as having very difficult obstacles. Based on several statements in the questionnaire regarding the limited understanding of concepts, it was found that most students answered that they understood the concepts and examples of questions given, but when they were given an assignment with slightly different questions, they became confused. The results of the interviews reinforce it.

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Based on the results of interviews, it is known that students already understand the concept of using integrals to determine the area of the flat area between two curves. The student uses the formula $A = \int_a^b (f(x) - g(x))\, dx$. However, because the students' understanding of the concept was limited, they had difficulty solving the problem. Thus, it can be said that students experience epistemological obstacles related to limited understanding of concepts.

*Epistemological Obstacles Related to Error Analyzing Problems*

Epistemological obstacles related to errors in analyzing questions are obstacles that occur when students find it difficult and make mistakes in analyzing questions. This epistemological obstacle is shown in Figure 7.

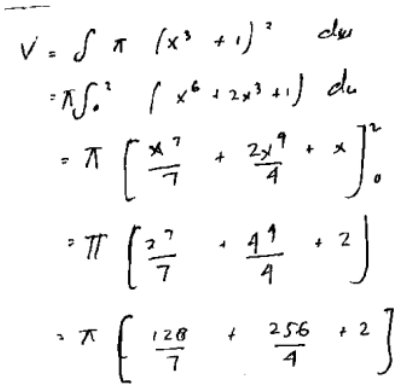

Figure 7. Student's Answer Sheet on Epistemological Obstacle Related to Errors in Analyzing Questions

Based on the answers, it can be seen that the student can understand the concept of calculating the volume of a solid object. It shows that there is an error in analyzing the problem. From the picture, it can be seen that the student solved the problem using the disc method to calculate the volume of a solid object that would be produced when the known R area was rotated around the x=4 axis. Instead, the disc method should be used to calculate the volume of a solid when a known area is rotated around the x-axis. Meanwhile, in this question, to calculate the volume of the solid object in question, the cylinder shell method should be used.

Based on the interview results, it is known that the student already understands the concept of the volume of a solid object and knows that the technique used to solve the problem uses the disc method. However, the student made an error when analyzing the questions. The cylinder shell method should be used if the area is rotated around the x = 4 axis. Thus it can be said that students experience epistemological obstacles related to errors in analyzing questions.

Based on several statements in the questionnaire regarding errors in analyzing the questions, it was found that most of the students answered that they found it difficult to use which method to

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solve the questions. This can also be seen from the results of the questionnaire analysis given. An average of 3.2 was obtained, categorized as having obstacles in the difficult category.

## Didactic Obstacle

Didactic obstacles are learning obstacles that occur in students related to teachers and teaching materials. The inappropriate approach model causes this obstacle carried out by the teacher or lecturer and the teaching materials used. In other words, this obstacle occurs because of the teacher's mistakes in designing the learning process and in its implementation and inappropriate teaching materials. Didactic obstacles are also caused by the application of learning models or methods that are not following the material being taught and the student's abilities. Didactic obstacles are also caused by material skipping or inefficient repetition of material (Prasetyo et al., 2020). In this study, didactic obstacles were analyzed based on the inaccuracy of teaching materials and teaching methods.

### *Didactic Obstacle Related to Teaching Materials*

One type of didactic obstacle is the obstacle related to the inaccuracy of teaching materials. This obstacle occurs when students find it challenging to understand the teaching materials used. Based on the analysis of the questionnaire results, an average of 2.7 was obtained, which was categorized as having obstacles in the medium category. Based on several statements in the questionnaire regarding the inaccuracy of teaching materials, it was found that most students answered that they found it difficult to understand the textbooks used in calculus courses. In addition, the examples of questions presented and the language used in the textbooks are also quite tricky to understand. Based on the results of the interviews, it is known that the textbooks used are quite challenging to understand, especially in the sample questions section. Detailed steps are not given in the sample questions section, so it confuses students. The teaching materials used are not following the abilities possessed by most students. It causes didactic obstacles related to teaching materials.

### *Didactic Obstacle Related to Teaching Method*

This obstacle occurs when students find it challenging to understand the material being taught because it is caused by an inappropriate approach model made by the teacher or lecturer. In other words, this obstacle occurs because of the teacher's mistakes in designing the learning process and its implementation. Didactic obstacles are also caused by the application of learning models or methods that are not following the material being taught and the student's abilities. Based on the analysis of the questionnaire results, an average of 2.8 was obtained, which was categorized as having obstacles in the medium category. Based on several statements in the questionnaire regarding the inaccuracy of teaching methods, it was found that most students answered that they

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found it difficult to understand the material with the teaching methods carried out by the lecturers. The method used by the lecturer is online, by making videos explaining the material. Most of the students had difficulty understanding videos and participating in online learning. It is because the interaction between students and lecturers is not direct or face-to-face, so when students face obstacles, they have difficulty and tend to be shy to ask questions.

## Ontogenic Obstacle

Ontogenic obstacles are learning barriers caused by restrictions on knowledge or concepts experienced by students during self-development related to mental readiness to learn. This obstacle is also caused by the provision of material that is not following the students' abilities. Based on the analysis of the questionnaire results, an average of 2.1 was obtained, which was categorized as having no obstacles. Several statements in the questionnaire regarding readiness to learn calculus found that students were ready to study calculus material because it was following their thinking abilities. In addition, it was also found that they had studied the prerequisite material of limits, derivatives, and integrals in high school. Based on the results of the interviews, it was also known that the material provided followed their readiness to learn. So, in general, there are no ontogeny obstacles in calculus courses.

Thus, this study's obstacles are didactic and epistemological. The didactic obstacles in this study are related to teaching materials that are difficult to understand and teaching methods that are not appropriate. The online teaching method causes students to have difficulty understanding the material. Thus, to overcome these didactical obstacles, teaching materials are needed that follow the characteristics and teaching methods. Furthermore, the epistemological obstacles are related to conceptual errors, limited understanding of concepts, and errors in analyzing questions. Therefore, to overcome epistemological obstacles, it is necessary to choose the proper method so that students can understand the concept well so that in the learning process, there are no misconceptions. Thus, students are expected to be able to relate one concept to another.

## CONCLUSION

This study concluded that there are five types of errors made by students in solving mathematical problems in a calculus course: conceptual, algorithm, calculation, algebraic operations, and careless errors. In addition, there are two types of learning obstacles experienced by students in calculus courses: epistemological obstacles related to conceptual errors, limited understanding of concepts, errors in analyzing questions, and didactic obstacles related to difficulties in understanding teaching materials and inaccuracy of teaching methods. Further research is needed to overcome learning obstacles that occur by developing appropriate learning materials according to the abilities and characteristics of students and applying appropriate learning models and methods.

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