p-ISSN: 2086-4280
e-ISSN: 2527-8827

Analyzing Learning Obstacles in Differential Calculus: A Case Study of Pre-Service Mathematics Teachers in Indonesian Regional University

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Article received: 18-05-2025, revision: 28-06-2025, published: 30-07-2025

Abstrak

Mahasiswa sering mengalami kesulitan dalam perkuliahan kalkulus diferensial. Tujuan penelitian ini adalah menganalisis karakteristik dari kesulitan belajar kalkulus diferensial pada mahasiswa calon guru matematika. Metode penelitian adalah kualitatif deskriptif dengan 39 mahasiswa dari dua Perguruan Tinggi Swasta di Banten, Indonesia. Data dikumpulkan melalui tes kesulitan belajar, wawancara, fokus grup diskusi (FGD) dan studi dokumen, dianalisis dengan teknik identifikasi, klarifikasi, reduksi, dan verifikasi secara naratif. Temuan penelitian menunjukkan 81% mahasiswa mengalami kesulitan pada aspek ontologis, 86% pada aspek didaktis, dan 73% pada aspek epistemologis. Solusi yang muncul dari wawancara dan FGD berupa kebutuhan mahasiswa terhadap buku sumber belajar yang interaktif dengan adanya elemen digital seperti video pembelajaran dan akses barcode. Pengembangan desain e-didaktis yang mengintegrasikan media digital ini tidak hanya membantu mengurangi hambatan belajar mahasiswa, tetapi juga berpotensi meningkatkan pemahaman konseptual sekaligus kemampuan aplikatif mereka dalam kalkulus diferensial. Learning obstacle ini menjadi pertimbangan bagi dosen dalam merancang desain e-didaktis pada kalkulus diferensial.

***Kata Kunci**: Desain e-didaktis; Hambatan Belajar; Kalkulus Diferensial; Mahasiswa Calon Guru Matematika.*

Abstract

Students often face challenges in differential calculus lectures. The purpose of this study was to analyze the characteristics of learning obstacles in differential calculus. The research employed a qualitative descriptive approach involving 39 students from two private universities in Banten, Indonesia. Data were collected through learning obstacle tests, interviews, focus group discussions (FGDs), and document studies, then analyzed using identification, clarification, reduction, and verification techniques in a narrative manner. The findings revealed that 81% of students experienced difficulties in the ontological aspect, 86% in the didactic aspect, and 73% in the epistemological aspect of differential calculus. Interviews and FGDs further confirmed the existence of these obstacles and explored potential solutions. One solution that emerged was the need for interactive learning resources incorporating digital elements such as instructional videos and barcode access. The implication of these findings indicates that developing an e-didactic design integrating digital media not only helps reduce students' learning obstacles but also has the potential to enhance their conceptual understanding and applicative skills in differential calculus. Overall, these learning obstacles provide important considerations for lecturers in designing effective e-didactic materials for differential calculus courses.

Keywords: E-Didactic Design; Learning Obstacles; Differential Calculus; Prospective Mathematics Student Teachers.

I. INTRODUCTION

Differential calculus is one of the mandatory courses for students in the fields of engineering, science and mathematics education, because it is a very crucial foundation in developing the ability to use structured logic, analytical reasoning and critical thinking (Alam, 2020; Klein M, et al, 2021; Ruamba, 2025). However, the low learning outcomes of students, especially in small private universities in the countryside are a major concern (Ario et al., 2020; Meika et al., 2023). Students' low understanding of Differential Calculus material has the potential to hinder the achievement of expected learning targets, affect advanced courses and in general will significantly affect the achievement of the Grade Point Average (Puspita et al., 2020; Prihandhika & Azizah, 2025).

According to Brousseau (Musyrifah et al., 2022; Nurhayati & Gunawan, 2024), learning obstacles consist of three categories: ontogenical obstacles (originating from students' cognitive limitations and prior knowledge), didactical obstacles (arising from teaching approaches and instructional design), and epistemological obstacles (stemming from the inherent complexity of the mathematical content itself). These three types provide a conceptual framework to analyze difficulties in learning differential calculus.

Various things related to learning Differential Calculus are interesting studies for researchers. Many researchers have investigated various causes of difficulties and topics in calculus that are considered problematic by students, including those related to the concept of asymptotes in functions (Katalenić, et al, 2023), limit (Kidron, 2020; Jameson, et al., 2023; Oktaviyanthi et al., 2024), derivative (Quezada, 2020; Musyrifah et al., 2022; Chen, Y, 2023; Puspita et al., 2023; Kurniadi et al., 2025), and the use of derivatives on instantaneous rates of change (Fonseca & Henriques, 2023). Musyrifah et al. (2022) revealed that the students' difficulties in understanding and applying a concept (for example derivatives) could potentially cause learning obstacles on knowledge of other related concepts. This study advances prior work by providing a comprehensive analysis of learning obstacles across the full scope of differential calculus content—from number systems, functions, and limits to derivatives and their applications—within the under-researched context of small private universities in Indonesia.

The obstacles or difficulties experienced by prospective mathematics teacher students in constructing knowledge are influenced by many factors, both internal and external (Latifah & Afriansyah, 2021). Quezada, (2020) stated that the results of the investigation had confirmed that teaching Calculus materials had different difficulties, both from a pedagogical, epistemological and psychological perspective. In line with this, Rosjanuardi et al. (2022) states that obstacles are an integral part of the learning process. According to Brousseau (Musyrifah et al., 2022) learning obstacles consist of three categories, namely ontogenical obstacle, didactical obstacle, as well as epistemological obstacles.

Based on this gap, the present study addresses the following research

p-ISSN: 2086-4280
e-ISSN: 2527-8827

questions: 1) What types of learning obstacles (ontogenical, didactical, epistemological) are experienced by prospective mathematics teacher students in differential calculus? 2) To what extent do these obstacles occur across different calculus topics? 3) What implications do the identified obstacles have for the design of effective e-didactic learning materials?

Lack of in-depth analysis of learning obstacles makes low student abilities difficult to overcome. The results of observations and interviews with prospective mathematics teacher students at Mathla'ul Anwar University and La Tansa Mashiro University show that learning.

II. METHOD

This research method was carried out using a descriptive qualitative approach. The aim of this research is to analyze the difficulties of learning Differential Calculus. The research stages to achieve this goal are (1) preparing question and interview instruments, (2) conducting tests on students who have completed Differential Calculus courses, (3) Focus Group Discussion (FGD), and (3) compiling research results.

This research involved 39 students from the mathematics education study program who had completed Differential Calculus courses at two private universities in Banten. A total of 18 students were from Mathla'ul Anwar University in Pandeglang, and 21 from La Tansa Mashiro University in Lebak. To obtain in-depth insights, 12 students were purposively selected based on variation in gender, prior calculus achievement, and representation from both universities for further analysis and semi-structured interviews. Demographic information, including university affiliation, gender distribution, and prior calculus grades, is presented in Table 1.

Table 1.
Demographic Information, University Affiliation, Gender Distribution, and Prior Calculus Grades

University	Subject	Prior Calculus Grade	
		Male	Female
UNMA	S1	78.24	
	S2	70.00	
	S3	46.63	
	S4	53.05	
	S5		57.08
	S6		60.72
	S7		58.44
	S8		60.24
	S9		52.968
	S10		54.40
	S11		55.68
	S12		61.20
	S13		64.96
	S14		60.40
	S15		72.00
	S16		57.20
	S17		57.60
	S18		62.88
UNILAM	S19	61.48	
	S20	71.28	
	S21	60.4	
	S22	66.32	
	S23	66.08	
	S24		56.08
	S25		55.12
	S26		74.72
	S27		60.24
	S28		56.48
	S29		60.4
	S30		60
	S31		60.48
	S32		52.688
	S33		59.568
	S34		71.28
	S35		63.12
	S36		51.92
	S37		64.96
	S38		69.52
	S39		68.88
Mean		63.72	60.71

Data is collected through Learning Obstacle (LO) test, interviews, focus group discussions (FGD), and document studies. Both test and interview instruments have been validated. The test instrument consists of five descriptive questions consisting of introductory questions on the real number system, algebraic function limits, derivatives, and the use of derivatives. The LO test is carried out to find out where students made mistakes in solving questions so that they can analyze the difficulties they face. Interview techniques were carried out to dig up deeper information regarding the difficulties experienced by students in working on these questions. Meanwhile, FGD was carried out to reconfirm the LOs faced by prospective mathematics teacher students and the solutions expected by these students.

The collected data is then identified and categorized based on the type of obstacle, such as conceptual misconceptions, difficulties in applying theory to practice, or external factors such as lack of learning support. Next, the categorized data is analyzed using a thematic approach to reveal characteristics of learning obstacle. This analysis was also followed by data triangulation to ensure the validity of the results by comparing the results from the LO test, interviews and FGD. After that, the results of the analysis are interpreted to draw conclusions regarding the most dominant characteristics of LO, and are used to formulate implications for teaching differential calculus.

III. Result and Discussion

This research data was obtained from test results Learning Ostacle (LO) Differential Calculus carried out by 39 students from two private universities inBanten, namely Mathla'ul Anwar University and La Tanza Mashiro University. This test consists of five essay questions consisting of introductory material on the real number system, limits of algebraic functions, derivatives of algebraic functions and trigonometric functions, as well as the use of derivatives. The LO test results show that students experience difficulties (learning obstacle) in working on the questions. Based on the LO test results data, general data is obtained which is presented in Table 2 below:

Table 2.
Description of Test Results of Differential Calculus Learning Obstacle

Number of items	Learning Obstacle		
	Ontogenical	Didactical	Epistemo logical
1	79%	95%	54%
2	56%	67%	56%
3	85%	90%	79%
4	92%	87%	87%
5	90%	90%	87%
Average	81%	86%	73%

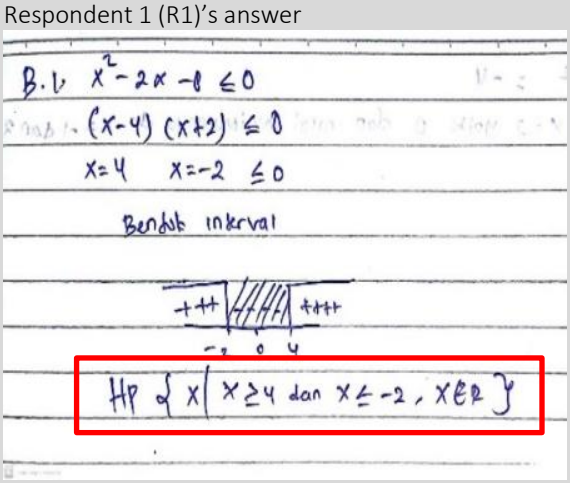
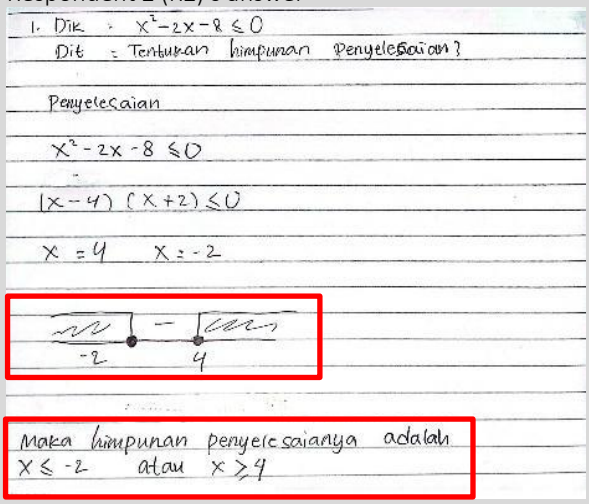
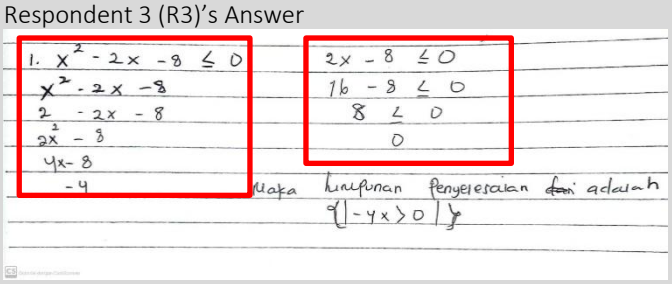
Based on Table 1 it can be seen that on average learning obstacle of prospective mathematics teacher students in the Differential Calculus course that belongs to ontogenical obstacle reached 81%, didactical obstacle 86% and obstacle epistemological obstacle 73%. Detailed explanation regarding characteristic analysis in learning obstacle is presented in Table 3 to Table 6.

Analysis of the results of student work on the item number 1 in Differential Calculus LO test can be seen in Table 2. As

p-ISSN: 2086-4280
e-ISSN: 2527-8827

for the question item of Differential Calculus LO test questions number 1 is : "Determine the solution set of: x^2-2x-8≤0".

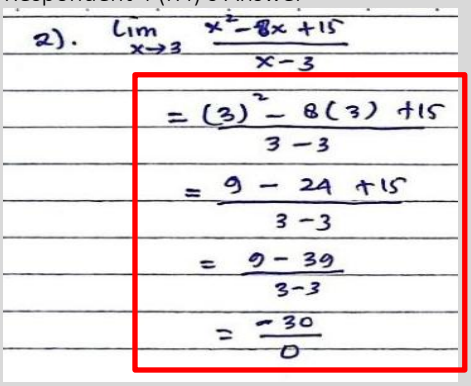
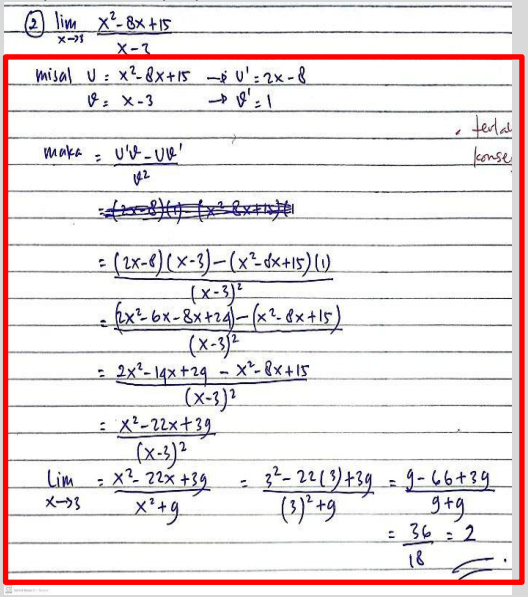
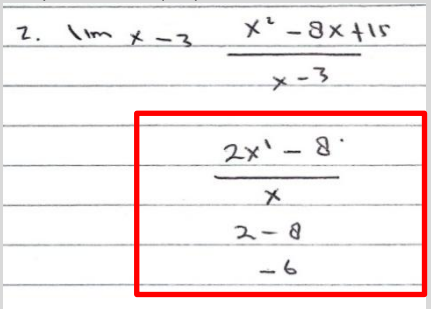
Table 3.
Analysis of Student works on the Differential Calculus LO Test Number 1

Student's Answer	Analysis of the Learning Obstacle
Respondent 1 (R1)'s answer  Respondent 2 (R2)'s answer 	**Epistemological Obstacle**: In this answer, R1 answered by factoring the quadratic equation and continued to determine the sign of inequality with the solution interval, but R1 was wrong in determining the solution set so that there was a mismatch between the interval and the solution set. Epistemological obstacle happened again to R2 student, it appears that R2 has done factorization and determined the inequality sign with the solution interval. In the final solution it can be seen that R2 does not understand how to determine the set of solutions from the solution interval that he has determined.
Respondent 3 (R3)'s Answer 	***Ontogenical Obstacle*** Based on R3's answer, students cannot decide interval limits of inequalities question number 1. R3 does not control how to factor equations squared so he cannot solve it correctly.

Furthermore, the analysis of the results of students' work on Differential Calculus LO

test number 2 can be seen in Table 4. As for question number 2, namely: "Determine the results of $\lim_{x\to 3} \frac{x^2-8x+15}{x-3}$

Table 4.
Analysis of Students' Answers on the Differential Calculus LO Test on Question Number 2

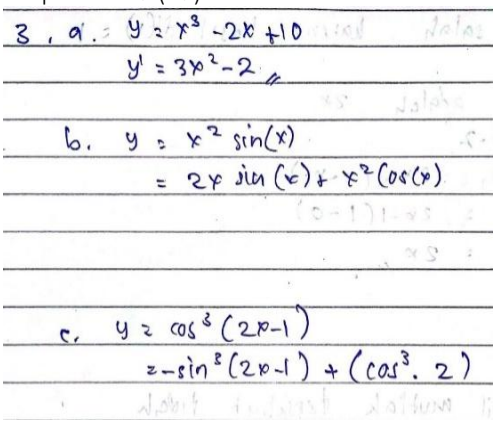
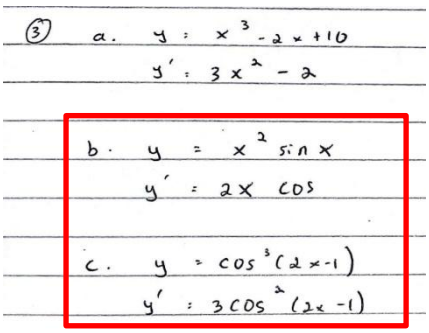
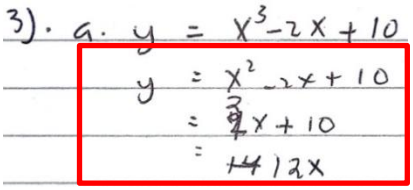
Students' Answers	Analysis of the Learning Obstacle
Respondent 4 (R4)'s Answer 	**Epistemological Obstacle** Based on student's answers on question number 2, it can be seen that R4 experienced a conceptual error the solution to the problem, as it should be factoring is done first, the student directly substituting the limit x into the function. The student did not understand that steps to solve the problem it should not be direct.
Respondent 5 (R5)'s Answer 	**Epistemological Obstacle** Student R5's answer was that he did not understand given problem or question given which gives rise to misunderstandings in the solution.
Respondent 6 (R6)'s Answer 	**Ontogenical obstacle** Student R6's answer shows that he did not know how solve problem number 2. It indicates student unpreparedness related to matters technical aspects that are key to the learning process.

Analysis of the results of student work on the LO Differential Calculus test number 3 can be seen in Table 5. The Differential Calculus LO test questions number 3 are: "Find the first derivative of: a) $y = x^3 -$

p-ISSN: 2086-4280
e-ISSN: 2527-8827

$2x + 10$ b) $y = x^2 \sin x$, and c) $y = x^2 \sin x$.

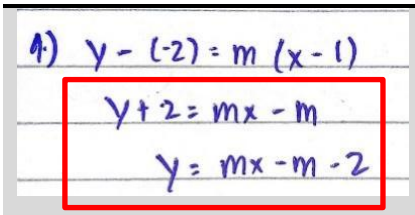
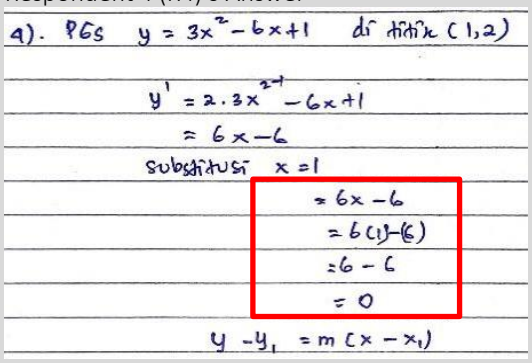
Table 5.
Analysis of student answers on differential calculus LO test question number 3

Students' Answer	Analysis on Learning Obstacle
Respondent 7 (R7)'s Answer 	*Ontogenical obstacle* Students don't understand that steps to solve the problem should be done with using the concept of chain derivatives. The questions given are questions that can be done with use derivative concepts, if possible, doing questions a and b means question can be resolved. Student answers above shows that there is incompatibility of demands for deep thinking learning.
Respondent 8 (R8)'s Answer 	Ontogenical obstacle R8 student cannot solve questions number 3b and 3c, students can only complete question 3a because it uses concepts ordinary derivative while question 3b is type trigonometric derivatives questions and 3c uses the concept of chain derivatives student R8 does not understand the concept to finish it.
Respondent 9 (R9)'s Answer 	Epistemological Obstacle Student R9's answer shows don't understand the concept of derivatives, which means there are student limitations in mastery and understanding about a concept.

Analysis of the results of student work on the Differential Calculus LO test number 4 can be seen in Table 5. The Differential Calculus LO test questions number 4 are: "Find the equation of the tangent line at $y = 3x^2 - 6x + 1$ in point (1,-2)".

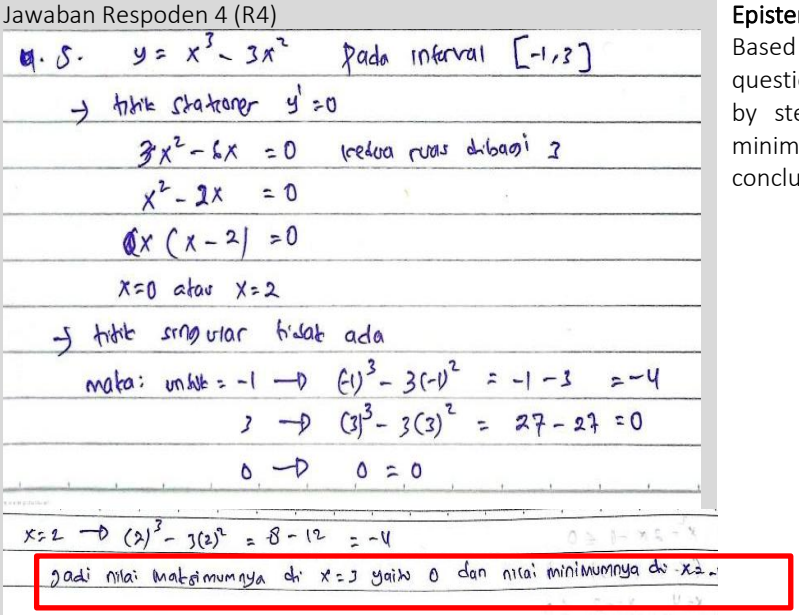
Table 6.
Analysis of student answers on differential calculus LO test question number 4

Students' Answer	Analysis of Learning Obstacle
Respondent 10 (R10)'s answer	Ontogenical obstacle Based on student answers on Question number 4 is not possible complete the answer for find the equation of the tangent line just write down the equation formula the tangent without searching first the gradient.

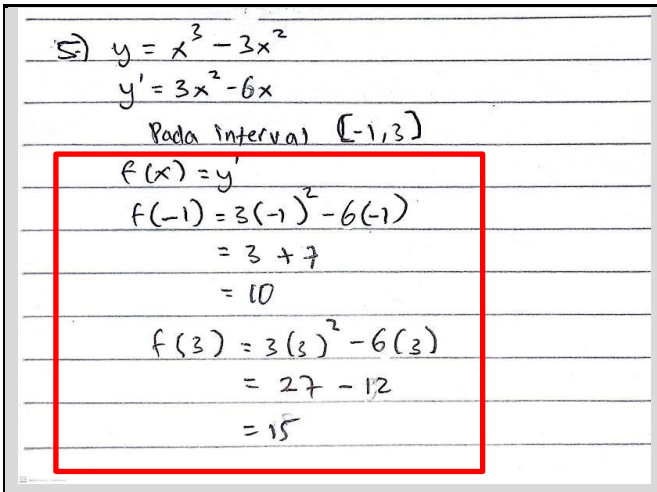
Students' Answer	Analysis of Learning Obstacle
	
Respondent 4 (R4)'s Answer 	**Ontogenical obstacle** Students can go through the steps to determine the equation tangent but at the moment determining the student gradient does not knowing what is known, so that R4 cannot continue the next step is substitute into the formula tangent line equation.

Analysis of the results of student work on the Differential Calculus LO test number 5 can be seen in Table 6. The Differential Calculus LO test questions number 5 are: "Determine the local maximum and minimum of the curve kurva $y = x^3 - 3x^2$ in interval [-1,3]".

Table 7.
Analysis of student answers on LO differential calculus test question number 5

Students' Answer	Analysis Learning Obstacle
Jawaban Respoden 4 (R4) 	**Epistemological obstacle** Based on students' answers on the question number 5 for concept and step by step are true but when deciding minimum value and maximum at time concluded is still not appropriate.
Respondent 11 (R11)'s Answer	**Ontogenical Obstacle** The student substitute known interval into the wrong equation. Thus, they could not find the maximum value and value minimum correctly

p-ISSN: 2086-4280
e-ISSN: 2527-8827

Students' Answer	Analysis Learning Obstacle
	

Based on learning obstacle were found in the students' answers to the 5 differential calculus questions given learning obstacle. Menurut Brousseau (Cesaria & Herman, 2019; Nurhayati et al., 2023) that barriers to learning can originate from three things, namely: 1) mental readiness and cognitive maturity of students in receiving knowledge (ontogenical obstacle); 2) sequence of material in the textbook or presentation by the lecturer in class (didactical obstacle); or 3) limited student mastery and understanding of mathematics (epistemological obstacle). Three characteristics of learning obstacle has been found in this research are described as follows:

A. Ontogenical obstacle

Ontogenical obstacle is a psychologically based learning difficulty, students experience learning difficulties due to mental readiness factors. This learning barrier arises because students are unprepared regarding technical matters key to the learning process (Maharani et al., 2022). Ontogenic obstacle occurred in respondents 7, 8, 10, 4 and 12 in solving questions number 3, 4 and 5.

Based on the answers of respondents 7 and 8 in solving question number 3, students were unable to solve the question at the last stage because the question given was a question that could be done using derivative concepts. Question 3a is related to derivatives of algebraic functions with an easy level of difficulty, continues with question 3b is related to derivatives of algebraic functions and trigonometric functions using the multiplication rule of two functions, and 3c is related to chain derivatives of trigonometric functions. Questions in parts a, b and c are arranged in stages from easy, medium to difficult. Students who understand the concept of derivatives well are likely to be able to complete parts 3b and 3c. However, students' answers R7 and R8 show that there is a mismatch in the demands for thinking in learning. This is another form of ontogenic obstacle conceptual concept of derivative, where students do not yet understand the prerequisite concept of derivative. R8 cannot solve questions 3b

and 3c. R7 cannot complete 3c. To find out the students' reasons for working on these questions, interviews were conducted as follows:

A : In question number 3 parts a and b can be solved well, why is part c not solved?

R7 : eemm that ma'am if number 3a and 3b in my opinion the question given is easy if the part c is forgotten how to continue to see because it cannot be directly diturinin. I've actually done something like that but I'm confused about it, because I have to use the concept of chain derivation.

A : If it's R8, why can't question number 3b be solved correctly?

R8 : If question number one is quite easy, just take it straight down to get the results. But if 3b and 3c are trigonometry questions, I can't do trigonometry, ma'am.

Based on the answers from the interviews, students R7 and R8 experienced ontogenic obstacle, it can be seen from the students' answers that students cannot find the main key in solving chain derivative problems even though parts a and b can be solved. Ontogenic obstacle This did not only happen to respondents 7 and 8 but also happened to other students, namely respondents 10 and 4. Based on the answer to question number 4, student R10 did not complete his answer to find the equation of the line. R10 only wrote the tangent line equation formula without first finding the gradient. Meanwhile, R4 students were almost able to solve where R4 had determined the gradient but had not substituted it into the tangent line equation formula, so the answer was incomplete. To find out why R10 and R4 did not solve question number 4, an investigation was carried out through the following interview:

A : What are the problems with question number 4? eventhough questions number 1, 2, 3 can be solved well

R10 : emmm, I forgot ma'am, the concept of tangent gradient

A : Forgot which part?

R10 : um...I remember m is a gradient, but I forgot how to look for it in the context of a tangent line, so I immediately wrote down the equation of the tangent line using the formula ( ).

A : Why didn't R4 solve question number 4? Eventhough judging from the answer R4 almost solves it, the gradient has been obtained

R4 : eh, ma'am, I didn't realize that what I was looking for was a gradient, so I was confused about what to substitute in the formula... hehe

Based on the answers of students R10 and R4, they did not complete their answer to find the equation of the tangent line, because they forgot how to find the gradient, and did not understand what was known in the problem, so the problem was not solved. In line with the research results Meika et al. (2023) that the biggest causes of students' mistakes are still relying on rote methods to remember formulas and steps in solving questions, as well as students' inaccuracy in working on questions. Next results aanalysis Katalenić, A., et all (2023) demonstrate the

knowledge of prospective teacher students mathematics is fragmented and their work relies heavily on algebraic manipulation and memorization of calculus formulas. This shows that there are obstacles that arise due to students' unpreparedness regarding technical

p-ISSN: 2086-4280
e-ISSN: 2527-8827

matters which are key in the learning process. On the concept of line equations tangent, finding the gradient is one of the keys for students to be able to find the equation of the tangent line.

Student respondent 12 also experienced this ontogenic obstacle namely when answering question number 5. R12 substitutes a known interval into the wrong equation. So that they could not find the maximum and minimum values correctly, the student explained the reasons in the interview as follows:

A : What obstacles did you experience when solving question number 5?

R12 : Hmmm, ma'am, I forgot how to find the maximum and minimum values, all I remember is just reducing the equation, as far as I know, after that, immediately substitute it into the equation.

Based on the results of the test and interview answers, R12 did not find the key concept that must be used in solving the problem of question number 5. The concept that is understood is not strong and is not connected with other concepts, so students do not understand important things and when a concept is used. for problem solving.

Proposed Solutions from the FGD

To overcome ontogenic obstacles, the FGD suggested strengthening prerequisite concepts through remedial teaching and scaffolding, emphasizing conceptual understanding rather than memorization, and using problems arranged in stages. Lecturers are also advised to provide step-by-step guidance with problem-based learning, facilitate group discussions, and conduct diagnostic assessments at the beginning to map students' readiness.

B. Didactical obstacle

Didactical obstacle is a student's learning difficulty that occurs due to misrepresentation. Types of learning barriers called didactical obstacle related to discrepancies in the didactic situation or learning process carried out. This obstacle can be caused by the teaching materials or resource books used by lecturers and students. Student learning resources and learning flows that are not aligned with the student learning process can give rise to problems Didactical obstacle This was found in La Tansa Mashiro University students during interviews where the learning resources were less helpful in learning differential calculus.

A : What learning methods are often used in learning differential calculus?

R6 : eh, usually, ma'am, the learning is grouped and tasks are given to understand the material to be studied, hmm, it continues to be presented at the next meeting

A : What learning resources are used in learning differential calculus?

R7 : if here (La Tansa Mashiro University) we usually use printed books, then usually if we don't understand the language in the book, we like to look for discussion videos on YouTube about the practice questions because in the practice book the questions are not fully discussed.

A : Are the books used based on recommendations from the

lecturer and do all students have those books?

R8 : no ma'am. If the book we ask to find the source yourself usually we use the source on google like electronic books and the source is different from friends.

A : Can the sources obtain help in learning? For example, in solving problems?

R9 : It's quite helpful ma'am, eh, but sometimes what we learn in books and on YouTube is usually different from what the lecturer teaches, for example the way to solve the questions is different.

A : What is needed from learning resources that can help in learning differential calculus?

R10 : I really want a book where every exercise has a question that is fully explained and can include an explanation video in the book, that's the one with a barcode so that it is easy for us to learn. The problem is that if you just read the book, it is hard to understand it... so you don't understand it.

Based on the interview results, it was found that students did not have appropriate learning resources in learning differential calculus, students looked for independent learning resources. Students are helped a lot by digital learning videos from YouTube, but they find it difficult when the sources are many and different and they haven't mastered the basic concepts. Finally, important concepts are not fully understood, this can lead to misconceptions and the level of understanding of concepts is limited to remembering or memorizing runes.

Didactical obstacle This happened again to students at Mathla'ul Anwar University who had book learning resources recommended by the lecturer but were not appropriate for students studying differential calculus. The following is an interview regarding the mismatch of learning resources in learning differential calculus:

A : What method do you think is effective in learning differential calculus?

R1 : Hmm, in my opinion, to learn differential calculus, you can't just read the book and understand it straight away, but you have to explain it first before you can understand, especially since the book we use has a short discussion, ma'am.

R2 : That's right Ma'am, I also agree eeemm often I don't understand even though it has been explained.

R3 : For me, ma'am, usually after explaining it, I have to ask a friend again, if I can't, I'll definitely ask a friend.

A : What are the learning resources (books Purcell) help you in learning differential calculus?

R4 : It's quite helpful, ma'am, I can read a little first before studying and the material discussed is the same as what was discussed with you.

R5 : But if I don't understand the language in the book, it's better to just listen to the explanation from you, if the book is incomplete and too short in discussing examples of questions.

Based on interviews conducted with Mathla'ul Anwar University students regarding the learning resources used,

p-ISSN: 2086-4280
e-ISSN: 2527-8827

namely purcell books l, Students are not helped in their learning. The books used require students to have strong prior knowledge of mathematics. Jameson, G., et al. (2023) recommend that lecturers must always check and ensure that students have appropriate prior knowledge before teaching new concepts in calculus.

The reality is that the students here are students who come from Vocational High Schools (SMK) who do not study mathematics in depth, there are also those who come from Senior High Schools (SMA) with social science classes, as well as Some students don't graduate from state universities, there are even students who don'' intend to go to college, just to fill their free time. So it can be ascertained that the background abilities of prospective teacher students at these private universities are still limited. On the other hand, differential calculus is an abstract and abstract subject Quezada (2020) stated that there is a relationship between the difficulty of mathematical thinking processes and the complexity of mathematical objects, and the level of student ability is thought to be the cause of the difficulties experienced (Puspita, E.. 2023).

Proposed Solutions from the FGD To address didactical obstacles, the FGD suggested designing localized textbooks that integrate full step-by-step solutions and interactive QR-linked videos. Lecturers should also curate a structured set of digital resources to avoid inconsistencies between online sources and classroom instruction. Furthermore, embedding collaborative tasks with guided worksheets can reduce students' reliance on fragmented self-learning.

C. Epistemologikal obstacle

Epistemological Obstacle are barriers to student learning caused by students' limited knowledge of concepts and learning experiences in certain contexts. The conceptual knowledge that students have can function well in certain problems, but because of students' limited learning experience, this knowledge cannot work well in other contexts. Epistemological obstacle happens if the person is faced with a different context, then the knowledge he has will become unusable, or he will have difficulty using it. This obstacle was found in respondents 1, 2, 3, 4 and 9 in solving questions number 1, 2 and 5.

Based on student R1's test answers, it was found that the student made an error in answering question number 1, namely the mismatch between the interval and the solution set. Meanwhile, student R2 in describing intervals is not appropriate. To find out the reasons why students make mistakes, interviews are conducted as follows:

A : How do you solve question number 1?
R1 : eee... factor first first, so that later you can find the x result of the factor ( )( ) after that we find the set of solutions using interval form.
A : Try looking at the answer in the solution set section? Is there something wrong?
R1 : Eeem, yes ma'am, that shouldn't be the answer, eee because I'm confused, Its symbol is the combination or so just use the writing "and" not symbols.

A : In answer of R2, why is describing the interval less precise?

R2 : That's it ma'am, I'm confused about deciding which area should be shaded and confused about determining the symbol when determining the solution set.

Based on the results of answers and interviews, it shows that students experience the boundary and related symbolic misconceptions. This is in line with research Jameson, G., et al. (2023), that students who have a wrong understanding of algebraic concepts will have difficulty applying constraints correctly.

Epistemological obstacle This also happened to respondents R4 and R5 in solving problem number 2, the student used the wrong concept in solving the problem, which should have been factored first because of his statement during the interview that the student was confused in factoring the equation, what happened was that the student immediately substituted the limit into the function. So that causes the denominator to become. To find out the reasons for students' answers, interviews were conducted as follows:

A : Look at your answer to number 2. Why is the denominator 0?

R4 : It should have been factored in first, but I tried it and couldn't find it, because the time is running out, just substitute the 3 straight away, so the denominator is 0

R5 : Eee that's it ma'am, I don't know how, because the limit is 3 I just substitute it straight away, replace everything with 3.

Based on this answer, the student had a wrong concept in solving the problem, which should have been factored first because of his statement during the interview that the student was confused about factoring the equation, what happened was that the student immediately substituted the limit into the function. So that causes the denominator to be 0, this shows that the student is experiencing conceptual misconceptions in the process. In line with research (Holmes et al., 2013) states that misconceptions are a framework of thinking which is not mathematically correct and tends to lead someone to the wrong thought process and answer.

Respondent 11 experienced obstacles epistemological obstacle In solving question number 5, based on the student's answer to question number 5 the concept and steps were correct, but when determining the minimum and maximum values it was not correct. To find out errors in solving question number 5, a search was carried out through interviews as follows:

A : Were there any difficulties when completing number 5?

R11 : I don't think so ma'am, I followed the steps that I learned during the lesson

A : But why did you determine the maximum and minimum values at the final conclusion?

R11 I did not double check the steps that were taken. Based on the analysis of the results respondent R11's answers and the results of the interview, it was clear that the student made mistakes when making decisions which caused inaccuracies in answering questions.

Data obtained from the results of measuring students' abilities using 5 description questions and the results of interviews that have been conducted can be concluded that there are obstacles in learning differential calculus which consist

p-ISSN: 2086-4280
e-ISSN: 2527-8827

of ontogenical obstacle, didactical obstacle and epistemological obstacle. The obstacles experienced are further discussed in Focus Group Discussion (FGD), which aims to unite perceptions regarding the obstacles experienced by students in the differential calculus course so that they can find solutions to overcome these obstacles. Through the FGDs that have been carried out, the challenges in learning differential calculus can be identified, namely:

1. Students often do not understand what is meant by derivative intuitively and mathematically. Students are confused about applying basic rules of differentiation, such as the chain rule.
2. Students have difficulty connecting the derivative of a function with the slope of the graph of that function.
3. Students have difficulty applying derivative concepts to real problems, such as speed, acceleration, and optimization.
4. A weak understanding of limits causes difficulties in understanding derivative definitions and concepts.
5. Students often have difficulty with the algebraic manipulations required to simplify functions before taking derivatives.
6. Students are often confused about the mathematical notation used in differentiation, like in $\frac{dy}{dx}, f'(x)$ and other.

The existing challenges in learning differential calculus can be resolved by meeting the need for facilities to help students understand the abstract concept of differential calculus, the use of appropriate teaching materials can be a solution to overcome the learning obstacles experienced, in line with research (Fitriani et al., 2020) learning obstacle can be overcome by using teaching materials that suit student needs.

IV. CONCLUSION

This study set out to answer three research questions: (1) What types of learning obstacles are experienced by prospective mathematics teacher students in differential calculus? (2) To what extent do these obstacles occur across different calculus topics? (3) What implications do the identified obstacles have for e-didactic design?

Prospective mathematics teacher students in differential calculus face various learning obstacles, including ontological, didactic, and epistemological obstacles. Ontological obstacles often appear in the conceptual and instrumental aspects. In the conceptual aspect, many students only memorize the material without deep understanding. This is evident when they struggle to solve problems if they forget the formula, such as difficulty distinguishing between direct derivative solutions, multiplication derivatives, and chain derivatives. Additionally, in the equation of the tangent line of a curve, many students do not understand the relationship between the concept of derivatives with gradients and the maximum and minimum values of the function. In the instrumental aspect, students tend to imitate example problems from textbooks or lecturers' explanations

without truly understanding the underlying concepts.

Didactic obstacles occur because the flow of material presentation is not well structured, which disrupts students' thinking processes and triggers misconceptions. Even though they have access to various digital learning resources like social media and YouTube, the inability to access primary learning resources that are well-directed hinders their understanding of basic concepts. Epistemological obstacles arise when students make mistakes in decision-making, leading to inaccuracies in solving problems, such as in the real number system material. This error often happens in finding the value of x in algebraic inequalities and in determining the correct sign when solving interval problems. These learning obstacles provide important insights for lecturers and researchers to reflect on the teaching and learning process. Improvements are needed to enhance the quality of mathematics education, including providing relevant, practical, and effective learning resources that align with the demands of the digital era.

ACKNOWLEDGEMENT

The authors express their sincere gratitude for the financial support provided by the Fundamental Research Scheme under the Ministry of Education, Culture, Research and Technology in 2024. This research was made possible and played an important role in the successful completion of this research. This abundant funding makes a major contribution to the conduct of research, data collection, and overall scientific progress in the field of Mathematics Education.

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