

Research Article

The Analysis of Students' Learning Difficulties in Solving Algebraic Function Derivative Problems in Higher Education

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Abstract

The purpose of the study was to describe the Mathematic department students learning difficulties in solving problems related to the Derivative of Algebraic Function method based on mathematical skills, and to identify the contribution factors. This study used a qualitative method to describes the students difficulties in solving derivative problems on algebraic functions. The subject of the study were 5 mathematic education students in their first semester of the 2024/2025 academic year on Calculus 1, Pawyatan Daba University of Kediri. The data collection used test and interview method. The result of the study showed that 60% of students experienced difficulties in arithmetics skill, 40% experienced difficulties in information skills, and 20% experienced difficulties in number fact skills. The factors that cause these learning difficulties are: 1) Difficulties in arithmetic skills, that is difficulties that caused by students inability to analyzed the appropriate algebraic derivation techniques for a problem and errors in solving the derivation procedure. 2) Difficulties in number fact skills, that is difficulties caused by don't understanding mathematical operational well, and 3) Difficulties in information skills, that is the difficulties that caused missreading and interpreting the questions.

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INTRODUCTION

Mathematics is a branch of science that is taught at all levels of education to equip students with logical, analytical, systematic, critical, and creative thinking skills. Mathematics is a source of knowledge that has many applications in other fields of science. Mathematics is studied at every level of education, so it is not only taught in elementary school, junior high school, and senior high school, but also continues through higher education. Translated with DeepL.com (free version) (Fatimah & Yerizon, 2019). One of the majors in higher education that explores and studies mathematics is the mathematics education program, which focuses on training students to become mathematics teachers (Fatimah & Yerizon, 2019). In the Mathematics Education study program, one of the compulsory courses that students must take is Calculus. Calculus is a basic course that serves as a prerequisite for taking other courses, so it is hoped that students will not encounter difficulties when studying those other courses later on (Monariska, 2019). Calculus is a branch of mathematics that consists of derivatives and integrals of functions in one dimension, covering topics such as velocity, acceleration, and optimization. In the Mathematics Education program at Pawyatan Daba University, calculus is a required course offered over three semesters, including Calculus I (differential calculus), Calculus II (integral calculus), and Advanced Calculus, ensuring that the three calculus topics are interconnected.

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In the mathematics education study program, students will learn a lot of material about mathematics. Due to the large amount of material that students must learn, it is common to find students who have difficulty learning mathematics (Sugiarti, 2018). In other words, students will encounter difficulties if differential calculus is not properly understood (Monariska, 2019). As explained, calculus is a continuous course whose basic concepts are found in differential calculus, according to (Monariska, 2019). If students have a solid understanding of differential calculus from the outset, this can serve as a benchmark for determining mastery of other calculus courses. Conversely, if students encounter difficulties in understanding calculus material at the beginning, this will impact their ability to master the calculus material covered in subsequent courses. In line with (Sugiarti, 2018), who states that one subject matter in mathematics is related to one or more other subject matters, meaning that if students have difficulty learning one part, it will affect their difficulty in learning other parts of mathematics. Calculus has also been studied at the high school level and will be studied in more detail at the university level. One of the topics to be taught in this course is the derivative of a function. Generally, the topics to be studied include the derivative of algebraic functions, the derivative of trigonometric functions, the chain rule, and applications of derivatives. Purcell, Verberg & Rigdon (2010) state that the concept of derivatives is an advanced mathematical concept that serves as a key to studying calculus after functions and limits. One of the competencies in learning derivatives is understanding the concept of derivatives and applying it to solve problems (Lestarianingsih et al., 2015), but in fact, calculus material is still considered difficult and boring for students, which results in poor learning outcomes (Fatimah & Yerizon, 2019); (Zin Mokhtar et al., 2013).

Learning difficulties are obstacles experienced by students in the implementation of learning or in receiving and applying a concept so that learning objectives are not optimally achieved (Machromah et al., 2018). In line with the statement by Djamarah (2008) and Sa'idah (2005), learning difficulties are a condition where students cannot learn something normally due to threats, obstacles, or disturbances during learning. The difficulties experienced by students in learning mathematics will affect their ability to solve exam questions. As stated by Soedjadi (1996), errors made when answering test questions are a result of the difficulties experienced by students. Based on interviews with five mathematics education students after they took their final exams for the 2024/2025 academic year, it was found that most students experienced difficulties in answering differential calculus exam questions due to various factors that caused them to make mistakes in answering differential calculus questions. This confirms that difficulties are the cause of errors, including strategic errors, calculation errors, conceptual errors, errors in making logical connections, errors in drawing conclusions, errors in using symbols, and carelessness in answering questions (Sugiarti, 2018).

These learning difficulties should receive attention from educators because they can affect students' performance in learning mathematics and its application in mathematical science. The difficulties experienced by students in solving math problems need to be analyzed further to identify the factors causing these difficulties, so that educators can address the issues faced by students who make various mistakes in solving problems, thereby enabling them to achieve optimal test results (Kumalasari et al., 2016). Research (Tambychik & Meerah, 2014) indicates that there are five types of mathematical skills that form the basis of the difficulties students face in solving mathematical problems: number fact skill, arithmetic skill, information skill, language skill, and visual-spatial skill. In this study, the types of skills used to analyze students' difficulties are number fact skill, arithmetic skill, information skill, and language skill. This is because this study only examined Calculus 1 in the material on algebraic function derivatives and did not include its applications, so visual-spatial skills were not used. The purpose of this study was to describe the learning difficulties of mathematics education students in solving problems related to the material on algebraic function derivatives based on mathematical skills, as well as to identify the factors that caused these difficulties.

METHOD

The type of research used is qualitative research that describes the difficulties students face in solving algebraic function derivative problems. The subjects of this study were five students from the Mathematics Education program at Pwiyatan Daha University in Kediri during the 2024/2025 academic year who had taken the final exam for the Calculus I course. The data collection techniques used in this study were the test method and the interview method. The test was conducted to identify the location and type of difficulties students faced in solving Calculus I exam questions that included material on the derivatives of algebraic functions, based on the students' work. Meanwhile, the interview was conducted to reinforce and complement the written

test results and to directly obtain verbal responses regarding the difficulties and causes of difficulties students faced in solving the test questions. The data analysis stage used in this study was descriptive, using the Miles and Huberman model, as follows: 1) data reduction, which included correcting students' answers and analyzing the results of interviews with selected students by grouping them based on the difficulty of conceptual or calculation errors, use of strategies, or other errors; 2) data presentation, which involves presenting the data from the interviews with the selected students for analysis, and 3) drawing conclusions by comparing the results of the answers to the questions and the results of the interviews conducted, so that conclusions can be drawn from the results of the answers to the questions and the interviews.

RESULTS AND DISCUSSION

Results

The following are questions from the Final Semester Examination (FSE) with learning outcomes used to analyze students' difficulties in solving algebraic function derivatives.

Table 1. UAS Questions and Learning Outcome Indicators

Soal	Indikator Capaian Pembelajaran
Tentukan nilai $f'(x)$ dari fungsi dibawah ini:	
a. $f(x) = x^3 - 2x^2 + 3x$	a. Menyelesaikan dengan rumus sederhana turunan fungsi.
b. $f(x) = \frac{x^3+4}{2x+3}$	b. Menyelesaikan dengan rumus turunan pembagian.
c. $f(x) = (x^2 + 4x)^3$	c. Menyelesaikan dengan dalil rantai.
d. $f(x) = 5(x^2 + 2x - 1)^3$	d. Menyelesaikan dengan dalil rantai

Based on the results of the Calculus 1 final exam, students with the lowest average scores were selected, and five students were chosen as research subjects, namely those who made the most mistakes in the test. From these research subjects, it was found that 60% had difficulties in arithmetic skills, 40% had difficulties in information skills, and 20% had difficulties in number fact skills. Based on the test results and interviews conducted, the following data and information were obtained regarding the difficulties students faced in solving problems related to the derivatives of algebraic functions:

1. Information Skill

It is a skill to connect information and transform problems into mathematical sentences (Machromah, 2017) (Machromah et al., 2018). Difficulties in this aspect are identified through students' understanding of the questions given, their interpretation of the questions, and their use of appropriate mathematical models or algebraic manipulations of the problems given. The following are the areas where students make mistakes in their information processing skills.

$$f(u) = u^3 - 2u^2 + 3u$$

$$f'(u) = (u - 2u)^{3+2} + 3u$$

$$= -u^5 + 3u$$

Error in summing the exponents

Figure 1. Example of an incorrect answer to question number 3a

The mistake in Figure 1 is that the student did not write the answer using the derivative concept but wrote the answer using the power addition concept. Based on the results of interviews conducted with students, it was found that students worked by adding powers as follows: $x^3 - 2x^2 + 3x = (x - 2x)^{3+2} + 3x = -x^5 + 3x$. There appears to be an error in the student's interpretation of the question, where the student states that in

the previous chapter they had already worked on a question about exponentiation, so they applied the same method to work on this question, namely by adding the exponents.

2. Arithmetics Skill

This is a mathematical skill related to accuracy and logarithmic flow in calculations and solution procedures in mathematical models (Machromah, 2017). Students' difficulties in this skill were identified by observing their accuracy in determining the function reduction technique and their accuracy in using basic derivative concepts, as well as their accuracy in using the algorithmic flow of solutions in solving problems. Some of the students' errors in arithmetic skills are shown in the following figure:

$$F(x) = \frac{x^3 + 4}{2x + 3}$$

$$u = x^3 + 4, \quad u' = 3x^2$$

$$v = 2x + 3, \quad v' = 2$$

$$F'(x) = \frac{u'v - uv'}{v}$$

Carelessness in writing derivative formulas

$$= \frac{3x^2(2x + 3) - (x^3 + 4) \cdot 2}{2x + 3}$$

$$= \frac{6x^3 + 9x^2 - 2x^3 - 8}{2x + 3}$$

$$F'(x) = \frac{4x^3 + 9x^2 - 8}{2x + 3}$$

Gambar 2. Contoh Jawaban Salah soal nomor 3b

Figure 2 shows that students are not careful enough in writing the derivative formula, which should be written as $v^2 = (2x + 3)^2$, but students write $2x + 3$. From the interviews, it was found that students were not thorough and incomplete in writing formulas. Furthermore, when confirmed with the correct formula, these students were unable to solve the problems correctly. This indicates that these students did not fully understand the procedure for solving derivatives, thus making mistakes when solving problems..

$$f(u) = (u^2 + 4u)^3$$

$$f'(u) = u^{2+3} + 4u^3$$

Conceptual error in derivatives by adding up the values of exponents

$$= u^5 + 4u^3$$

$$f'(u) = 5u^4 + 12u^2$$

Figure 3. Example of an incorrect answer to question number 3c (1)

$$\begin{aligned}
 f(x) &= (x^2 + 4x)^3 \\
 &= x^{2+3} + 4x^{1+3} \\
 &= x^5 + 4x^4 \\
 f'(x) &= 5x^4 + 16x^3
 \end{aligned}$$

Conceptual error in derivatives by adding up the values of exponents

Gambar 4. Contoh Jawaban Salah soal nomor 3c (2)

$$\begin{aligned}
 &(u^2 + 4u)^3 \\
 F(u) &= u^3 \\
 F'(u) &= 3 \cdot u^{3-1} = 3u^2 \\
 u &= u^2 + 4u \\
 u' &= 2u + 4 \\
 F'(u) &= F'(u) \cdot u' \\
 &= 3u^2 \cdot (2u + 4) \\
 F'(u) &= 3(u^2 + 4u)^2 (2u + 4)
 \end{aligned}$$

Figure 5. Example of the correct answer to question number 3c

Figures 3 and 4 show the most common mistakes made by students in solving problems. The problem given is about the derivative of an algebraic function, which is solved using the chain rule, as shown in Figure 5. Students who solved the problem as shown in Figures 3 and 4 were identified as solving the problem using a simple derivative procedure for algebraic functions. Based on the interview process, the student who worked on Figure 3 explained that the derivation process they performed involved adding the exponents $(x^2 + 4x)^3 = x^{2+3} + 4x^3$ with the results written as $x^5 + 4x^3$. Next, students perform simple function derivation by writing down the final answer $5x^4 + 12x^2$. This error is also evident in Figure 4. The student who worked on Figure 4 also made a mistake in solving the derivative function using the chain rule. Similar to the results shown in Figure 3, the student wrote the answer by adding the exponents, but there is a difference between the two results of the student's work, namely $(x^2 + 4x)^3 = x^{2+3} + 4x^{1+3}$ with the results written as $x^5 + 4x^4$. Similar to the task in Figure 3, students performed simple function differentiation and wrote down an incorrect final answer, namely $5x^4 + 16x^3$. Based on the interview results, it was found that students understood how to solve derivative problems using this method, but they were not careful enough and rushed when working on the problems.

3. Language Skill

It is one of the mathematical skills related to the ability to understand mathematical terms and relationships based on available information (Machromah, 2017). Difficulties in language skills can be demonstrated by students' lack of understanding in interpreting mathematical terms and relationships in mathematical operations. In this study, students' difficulties in language skills in solving derivative function problems can be demonstrated by errors in creating mathematical models, errors in making assumptions, and errors in algebraic manipulation. Based on the analysis process, no errors were found in language skills.

4. Number Fact

This is a mathematical skill related to proficiency in number processing, table presentation, and mathematical principles (Machromah et al., 2018). Difficulties in number processing can be identified from students' errors in performing mathematical calculations, both numerical and variable calculations. Additionally, in this study, errors in simple integral calculations are also included in errors in number processing, which specifically indicate students' difficulties in number fact mathematical skills. Students' errors in number fact skills are identified in Figure 6.

The image shows a student's handwritten work for problem 3b. The work is on lined paper and shows several steps of algebraic manipulation. Two red boxes highlight specific errors:

- Top box:** Points to the expression $-(x^3 + 4) \cdot 2$. The callout says: "Kesalahan dalam menuliskan tanda '+'" (Mistake in writing the '+' sign).
- Bottom box:** Points to the expression $2x^2 + 3^2$. The callout says: "kesalahan dalam bentuk kuadrat $(a + b)^2 = a^2 + 2ab + b^2$ " (Mistake in the quadratic form).

The student's work shows the following steps:

$$= \frac{3x^2(2x+3) - (x^3+4) \cdot 2}{(2x+3)^2}$$

$$= \frac{6x^2 + 9x^2 - 2x^3 + 8}{2x^2 + 3^2}$$

$$= \frac{6x^2 + 9x - 2x^3 + 8}{2x^2 + 9}$$

$$= \frac{2x^3 + 6x^2 + 9x + 8}{2x^2 + 9}$$

Gambar 6 Contoh Jawaban Salah soal nomor 3b

In Figure 6, it can be seen that the student made a mistake in the multiplication calculation, where the student wrote $-(x^3 + 4) \cdot 2 = (-2x^3 + 8)$. Furthermore, the student also made a mistake in the operation $(2x + 3)^2$ which is a quadratic calculation with the form $(a + b)^2 = a^2 + 2ab + b^2$. Through the interview process, it was confirmed that the student wrote the answer $-(x^3 + 4) \cdot 2 = (-2x^3 + 8)$ because the student was not careful in paying attention to the signs of the numbers, and the interview continued with the student who wrote the answer $(2x + 3)^2 = 2x^2 + 3^2$. This indicates that the student did not understand the quadratic form, so the final answer written by the student was incorrect, namely $2x^2 + 9$. This is due to the students' carelessness in square calculations. Therefore, it can be concluded in Figure 6 that the students made mistakes in number fact skills, namely mistakes due to not understanding mathematical operations well.

Discussion

Based on the overall presentation of the types of difficulties in mathematical skills in solving algebraic function derivative problems, namely difficulties in information skills, arithmetic skills, and number fact skills. The results of this study indicate that there are several causes of students' difficulties in solving algebraic function derivative problems, namely: 1) students only rely on the solution method that was previously taught without analyzing the problem first, 2) they are unable to analyze the characteristics or types of problems, 3) their understanding of the basic concepts of integrals is incomplete and superficial, and (4) their basic mathematical skills, such as algebraic manipulation and accuracy in performing calculations, are insufficient. According to (Tall, 1993), the difficulties experienced in calculus include students preferring to use procedural solutions rather than understanding concepts, so that in the solution process, students tend to imitate what has been conveyed in class or what they have done before. Additionally, (Phonapichat et al., 2014) state that the difficulties students face in problem-solving include their inability to interpret problems, and if they cannot solve a problem, they will provide an answer without first engaging in thinking and analysis.

CONCLUSION

Based on the data above, it can be seen that 60% of the mistakes made by students in solving algebraic function derivative problems are caused by their difficulty in determining the appropriate method for deriving algebraic functions. In particular, there are mistakes in using the chain rule. This difficulty is part of the arithmetic skill type. In addition to experiencing difficulty in determining the method for deriving functions, students also make mistakes in the number fact skill and information skill types. This study also indicates that there are factors contributing to the difficulties in these skills, namely: 1) Difficulties in arithmetic skills are caused by students' inability to analyze the appropriate technique for deriving algebraic functions for a problem involving the derivative of an algebraic function and errors in the derivation procedure, 2) difficulties in number fact skills are caused by students' lack of understanding of mathematical operations, and 3) difficulties in information skills are caused by errors in reading and interpreting problems. With these findings, it is possible to identify the factors that cause learning difficulties. Educators are expected to pay attention to the learning difficulties students encounter in solving problems and the factors that cause these difficulties. By studying the results of this research, it is hoped that educators will be able to identify the learning difficulties students encounter in solving algebraic function derivative problems. Educators can then determine the appropriate and efficient teaching methods for teaching algebraic function derivatives so that learning objectives can be achieved.

BIBLIOGRAFI

- Djamarah, Syaiful Bahri. Psikologi Belajar. Jakarta: Rineka Cipta, 2008.
- Fatimah, S., & Yerizon. (2019). Analysis of difficulty learning calculus subject for mathematical education students. *International Journal of Scientific and Technology Research*, 8(3), 80–84.
- Kumalasari, E., Studi, P., Informatika, T., Teknik, F., & Ponorogo, U. M. (2016). *Analisis faktor kesulitan terhadap kesalahan penyelesaian soal persamaan linier berdasarkan klasifikasi Taksonomi Bloom (Studi kasus terhadap mahasiswa Teknik Informatika 2015 / 2016)*. 2(2), 113–122.
- Lestarianingsih, Y., Darmawijoyo, & Hartono, Y. (2015). Pengembangan Lembar Aktivitas Mahasiswa Topik. *Jurnal Pendidikan Matematika Dan Sains*, 3(1), 10–22.
- Machromah, Isnaeni Umi Purnomo, M. E. R., Febriyanti, K., & Rahmawati, H. A. B. (2017). Arithmetics Skill: Kesulitan Utama Mahasiswa dalam Menyelesaikan Soal Kalkulus Integral. *Seminar Matematika Dan Pendidikan Matematika, June*, 365–372.
- Machromah, I. U., Eriska, M., Purnomo, R., Febriyanti, K., & Ayu, H. (2018). *Arithmetics Skill : Kesulitan Utama Mahasiswa dalam Menyelesaikan Soal Arithmetics Skill : Kesulitan Utama Mahasiswa dalam Menyelesaikan Soal Kalkulus Integral. November 2017*.
- Monariska, E. (2019). Analisis kesulitan belajar mahasiswa pada materi integral. *Jurnal Analisa*, 5(1), 9–19. <https://doi.org/10.15575/ja.v5i1.4181>
- Pem-, D. A. N. (2005). *Problematika kesulitan belajar statistik*. 54–61.
- Phonapichat, P., Wongwanich, S., & Sujiva, S. (2014). An Analysis of Elementary School Students' Difficulties in Mathematical Problem Solving. *Procedia - Social and Behavioral Sciences*, 116(2012), 3169–3174. <https://doi.org/10.1016/j.sbspro.2014.01.728>
- Sugiarti, L. (2018). Prosiding Seminar Nasional Etnomatnesia KESULITAN SISWA DALAM MENYELESAIKAN SOAL OPERASI BENTUK ALJABAR. *Prosiding Seminar Nasional Etnomatnesia*, 323–330.
- Tall, D. (1993). Students' Difficulties in Calculus. *Proceedings of Working Group 3 on Students' Difficulties in Calculus, ICME-7, Proceedings of Working Group 3 on Students' Difficulties in Calculus, ICME-7*, 13–28. <https://doi.org/Canada>
- Tambychik, T., & Meerah, S. M. (2014). *Students' Difficulties in Mathematics Problem-Solving: What do they Say? Students' Difficulties in Mathematics Problem-Solving: What do they Say? December 2010*. <https://doi.org/10.1016/j.sbspro.2010.12.020>
- Zin Mokhtar, M., Ahmad Tarmizi, R., Fauzi Mohd Ayub, A., & Dato Hj Nawawi, M. (2013). Motivation and

Performance in Learning Calculus Through Problem-Based Learning. *International Journal of Asian Social Science*, 3(9), 1999–2005. <http://www.aessweb.com/journal-detail.php?id=5007>