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Derivative Problem Solving: Analysis of Problem-Solving Errors in Solving Derivative Material

Sri Wulandari[1], Caswita[2], Agung Putra Wijaya[3]
[1, 2, 3] University of Lampung
*Email: sriwulandariiii123@gmail.com

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ABSTRACT

Problem solving is a process that requires logical thinking to find solutions to the problems faced. Through this process, students will learn to develop appropriate stategies to solve the problems. This study aims to identify errors made by students in solving problems on the material of function derivatives. The method used in this study is descriptive, with dara collection techniques carried out through previous literature reviews. The results of the study showed that students made mstakes at several stages, namelin understanding the problem, designing a solution strategy, implementing the solution, and at the re-checking stage. Based on the type of error, students made mistakes in terms of facts, concepts, principles, and opertions. The proposed solution is to accustom students to be more careful in solving problems based on problem-solving steps, especially at the final checking stage, and to improve their mastery of algebraic operations and basic factoring techniques.

Keywords: *Problem-Solving, Analysis of Errors, Derivative of Functions.*

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INTRODUCTION

One of the common problems faced by many students in mathematics education is their inability to solve problems related to problem-solving (Zulkarnain et al., 2020). Although it is generally agreed that problem-solving skills are a crucial component in mathematics education (de Ron et al., 2022). However, in reality, the results of the implementation of learning so far indicate that students' ability to solve mathematics problems is still at a low level (Parwati et al., 2018). Problem solving is also one of the five process standards in mathematics education (Prayekti et al., 2020). Problem-solving skills are one of the main objectives to be achieved in the process of mathematics education (Zhang et al., 2022). Students need to have problem-solving skills that include the ability to identify problems and formulate appropriate solutions (Putri et al., 2022). Every problem requires a solution that depends on an individual's understanding and way of thinking when facing the situation (Miswandi Tendrita et al., 2022).

According to BSNP (Agusta, 2020), one of the goals of mathematics education is for students to develop skills in problem-solving, designing mathematical models, solving them, and interpreting the results of the solutions obtained. Problem-solving becomes an essential element in the mathematics curriculum because through this process, students are given the opportunity to apply their knowledge and skills in solving non-routine problems (de Ron et al., 2022) The problem-solving strategies that students possess need to be taught carefully, as this process requires students to formulate mathematical problems specifically and master various skills in representing those problems (Barham, 2020). Problem-solving is also an important element in completing mathematics education. This indicates that to develop creativity, logic, critical thinking, and systematic thinking, students need to master various problem-solving skills in mathematics, such as numerical, symbolic, verbal, or graphical representations (Setiyani et al., 2020).

This study, which focuses on students' abilities in mathematics, reading, and science, shows that students in Indonesia are still lacking in their ability to model and interpret mathematical problems into real-life contexts (Khotimah et al., 2022). One of the topics taught in mathematics is the derivative of algebraic functions, which is considered difficult by many students. This is due to the deep and abstract concepts within the material, as well as the fact that students often make mistakes in algebraic calculations and algebraic factorization (Sofyan & Pradipta, 2021) (Lestari et al., 2019). Difficulty is an obstacle in solving problems. To identify the difficulties students face in solving math problems, this can be done by giving test questions related to the material that has been learned (Lepertery et al., 2022) (Lepertery et al., 2022). From the analysis of students' work in solving derivative problems, it was found that students made mistakes in algebraic calculations as well as errors in factoring algebraic expressions (Maulin & Chotimah, 2023) (Meiliasari et al., 2021). Error is a form of deviation from the truth that occurs systematically and consistently, influenced by the student's level of competence, while incidental errors are caused by factors outside the student's competence. (Lubis et al., 2021).

The analysis of students' work in solving algebraic function derivative problems revealed several mistakes made by the students. These errors can be seen in Figure 1.

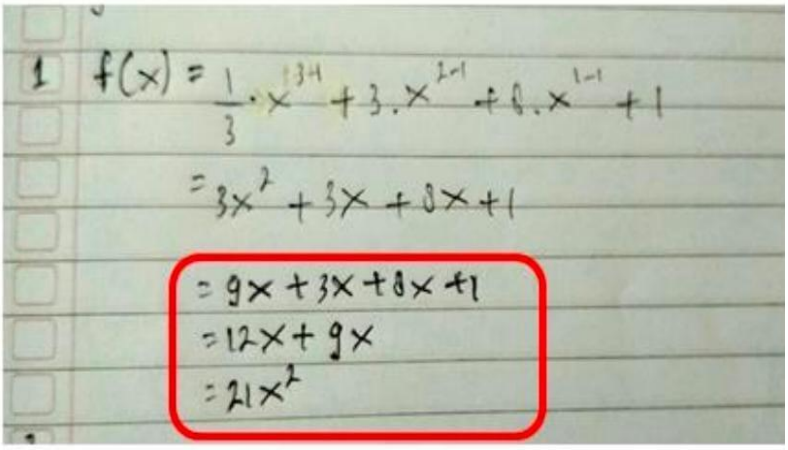

Figure 1. Example of students' mistakes in solving algebraic function derivative problems

Figure 1 shows that the student made a mistake in substituting the value of x into the function, which resulted in an indeterminate form, leading the student to conclude that the final result was the answer. This mistake includes both conceptual and operational errors, which are mistakes in performing calculations. The mistakes made by students in problem-solving need to be identified so that appropriate solutions can be found, preventing the same mistakes from recurring. Information about errors in problem-solving can be used to improve the quality of teaching and student learning outcomes.

This study aims to analyze the mistakes made by students in solving algebraic function derivative problems and offer solutions that can be applied to reduce these Problem-solving ability is one of the main competencies in mathematics learning, as stated in the process standards and learning objectives according to BSNP. However, field observations show that students still struggle to apply mathematical concepts, particularly in abstract topics such as derivatives of algebraic functions. This material requires both conceptual understanding and high technical skills, while many students tend to make systematic errors, both in understanding the concepts and in performing algebraic operations.

If these errors are not properly identified and addressed, they can accumulate and hinder the achievement of higher-level competencies. Therefore, it is important to analyze the errors that occur in the process of solving mathematical problems, particularly in the topic of derivatives of algebraic functions. The results of such analysis can provide a clear picture of students' areas of difficulty and serve as a foundation for improving learning strategies to be more effective and targeted. Most previous studies have focused more on general difficulties in learning mathematics or problem-solving in broader contexts. This study specifically analyzes problem-solving errors related to derivatives of algebraic functions, a topic known for its high complexity and frequent conceptual and procedural errors. This approach provides a more focused and in-depth mapping of student errors.

METHOD

It aims to provide a detailed and in-depth description of the errors found in previous journals or studies related to problem-solving in the topic of derivatives of algebraic functions. By employing a qualitative approach, this research focuses more on an in-depth analysis of findings presented in relevant literature.

The object of this research is the results of analyses from previous journals related to students' errors in solving problems involving derivatives of algebraic functions. This study does not involve direct interaction with student subjects, but instead relies on existing research documents. The selected journals are chosen based on their relevance to the topic under investigation, namely errors in mathematical problem-solving on the topic of derivatives of algebraic functions. The data in this research were obtained through literature review or journal analysis techniques. This technique involves the collection of relevant journals, both international and national, that discuss students' errors in solving mathematical problems, particularly in the context of derivatives of algebraic functions.

RESULTS AND DISCUSSION

The results of the analysis of students' mistakes in solving the daily mathematics test on the topic of Algebraic Function Derivatives, based on the stages of errors made by the students, are as follows:

1. Mistakes in Understanding the Problem

Mistakes in the problem understanding stage were made by two students, namely students TF02 and TF11. Both students made errors at this stage because they did not write down what was being asked in the question. Student TF11 even did not understand the derivative formula correctly.

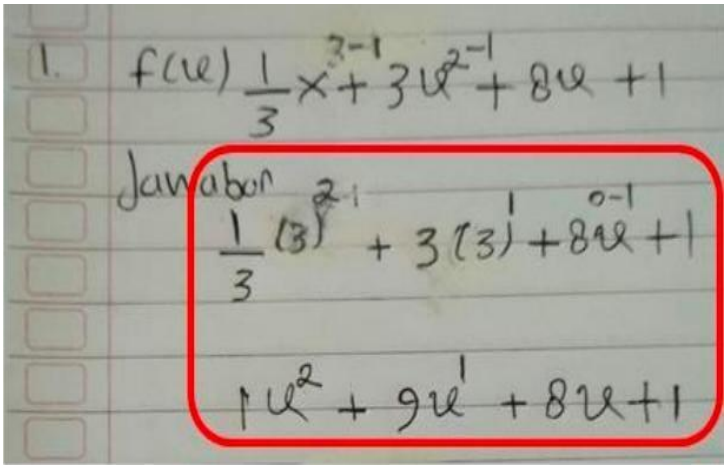

Figure 2. Student TF11's Work Results

Figure 2 shows that student TF11 made mistakes in both concept and operation. This is reinforced by the interview results, which can be seen in the following transcript.

P : In question number 1, why didn't you write the derivative notation?
TF11 : Because I was rushed for time, I just started working on it directly.
P : Then why didn't you include the variable x in your answer either?
TF11 : I forgot to replace it.
P : Then why was the coefficient still incorrect when integrating?
TF11 : I forgot how to integrate it.

Based on the interview results, it was found that student TF11 did not write the derivative notation and went straight to solving the problem due to being rushed by time. However, after a more in-depth interview, it was revealed that the student did not know how to solve the problem and did not even include the variable in the function. In general, conceptual errors can be influenced by various factors, one of which is the complexity of the mathematical concepts themselves. In addition to difficulties in understanding the concepts, the problems faced by teachers are also related to students' inability to understand the properties of an equation (Evianti et al., 2019). A misunderstanding occurs when students either do not know or fail to note the information provided in the question, and are unclear about the steps to take in solving the problem (Naisunis et al., 2018). TF11's inability to understand the problem or interpret the question led to the student being unable to determine a strategy to solve it, making the error fall under a conceptual mistake.

2. Mistake in Planning the Solution

There was one student who made an error in the planning stage of problem-solving, namely student TF06. This student made a second-stage error by not using the available information to solve the problem. Figure 3 shows that student TF06 made both conceptual and factual errors. The results of the analysis are supported by an interview conducted with student TF06, with the following transcript.

P : In question number 2, why is the perimeter of a square 2p + l?
TF06 : So, what is the correct one, Sir?
P : Try looking at your drawing, show which is the length and which is the width, how is the perimeter formula?
TF06 : Oh yes, 2p + 2l.
P : How could it be wrong?
TF06 : I forgot
P : What will you do next after you know the correct formula?
TF06 : Descended
P : Which one will be derived?
TF : Mmm.. I don't know

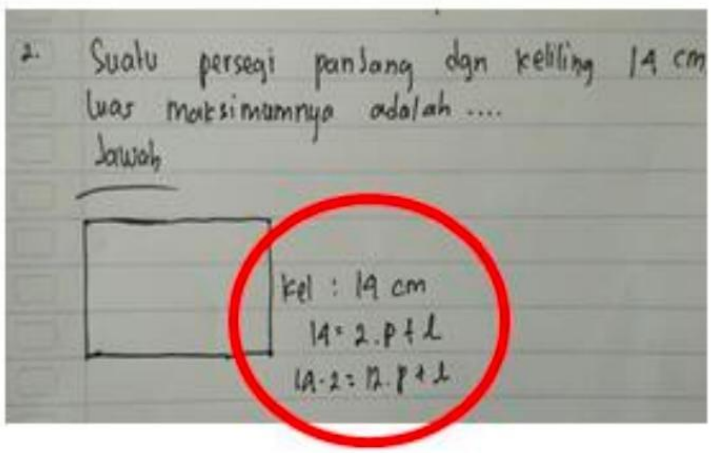

Figure 3. Work Results of Student TF06

Based on the interview results, it was found that student TF06 struggled to use the information provided in the question to solve the problem, resulting in an error in planning the solution. Student TF06 also made a conceptual error by failing to identify the function that represents the area of a rectangle, which led to an error in determining the formula of the function to be derived.

Additionally, student TF06 made a factual error because they could not correctly state the perimeter formula of a rectangle. This error was caused by a lack of attention or carefulness on the student's part regarding previous material.

3. Error in Solving the Problem

Errors in solving the problem were made by 16 students. The majority of students made an error in the third stage because they did not pay proper attention to the solution steps in solving the problem. These errors are shown in Figure 4.

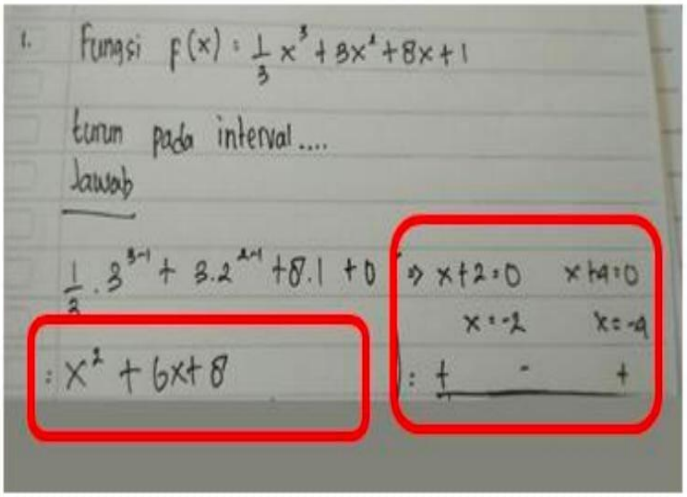

Figure 4. Work Results of Student TF07

Figure 4 shows the student making a conceptual error. The results of this analysis are clarified by an interview conducted with the student, with the following transcript.

P : After differentiating the function, why is the inequality sign greater than?
TF07 : Isn't the example problem also like that?
P : Try looking at the problem, does it ask for an increasing or decreasing interval?
TF07 : Decreasing
P : So, how should f'(x) be?
TF : I wonder how...??

Based on the interview results, it was found that the student did not follow the correct problem-solving steps. The error made was a conceptual mistake, as the student did not understand how to use the derivative of a function to determine the monotonicity interval of the function. Additionally, it can be seen that the student was not careful in solving the problem, as they incorrectly placed numbers on the number line, which affected the final result obtained.

4. Error in Rechecking

The rechecking stage in the problem-solving process was carried out by all students in completing the daily test, so all students made this error. This is further emphasized by the results of interviews conducted with two students, TF18 and TF20, with the following transcript.

P : Do you check your answers after solving the problems?
TF18 : I'm not used to it, so once I'm done, I just submit it right away.
TF20 : Because the time is up

perform rechecking due to not being accustomed to doing so and time constraints. The time constraint was due to the student still being busy working

on the problems, which meant the student needed more time than was available. This indicates that the student has not mastered the material well.

All students who were subjects of analysis in this study did not perform a re-check of their answers after completing the daily math test. Based on interviews with students TF18 and TF20, it was found that this was due to two main factors: an unformed habit and time constraints. Student TF18 admitted to not being accustomed to re-checking answers, while TF20 stated that the available time was insufficient because they were still focused on completing other questions.

The lack of habit in reviewing answers indicates a deficiency in students' metacognitive awareness during the problem-solving process. This may stem from learning patterns that do not emphasize the importance of reflecting on both the process and the results. In the context of mathematics education, re-checking plays a crucial role in ensuring the correctness of procedures and final outcomes.

The implication of this finding is the need to cultivate a culture or habit of re-checking in the learning process. Teachers can integrate structured re-checking practices, for example, by setting aside the last 5 minutes of exam or practice time to reflect and review answers. Such a strategy not only helps students form good habits but also strengthens their critical and systematic thinking skills. By fostering an awareness of the importance of re-checking and providing adequate time to do so, the mathematics learning process will become more comprehensive—not only focused on final results but also on the thinking processes involved.

Discussion

This study aims to identify and analyze the types of errors made by students in solving mathematics daily test questions on the topic of derivatives of algebraic functions. Based on the analysis of student errors, four main stages were identified where mistakes frequently occur: understanding the problem, planning the solution, solving the problem, and rechecking the solution. The following discussion elaborates on the main findings of this study and provides deeper insights into the causes and implications of the errors observed.

1. **Errors in Understanding the Problem**

Errors at this stage occur when students are unable to correctly identify or interpret the problem. For instance, student TF11 struggled to understand the derivative formula and did not note what was being asked in the problem. These errors generally arise because students fail to pay close attention to the given information or feel rushed. This is consistent with findings by Evianti et al. (2019), which showed that difficulties in understanding basic mathematical concepts often occur when students are unprepared for complex problems.

These errors are critical to address, as problem understanding is the foundation for mathematical problem-solving. If students fail to grasp the problem correctly, the subsequent steps in solving the problem will be hindered. Therefore, teaching should emphasize conceptual understanding and allow sufficient time for students to analyze problems. Teachers need to develop instructional techniques that help students identify key information in a problem and understand the problem-solving steps that must be taken.

2. **Errors in Planning the Solution**

At this stage, student TF06 experienced difficulty planning the steps needed to solve the problem. The student failed to utilize the information provided and

identify the correct formulas or procedures. Errors in this phase are often caused by a lack of understanding of broader concepts or poor recall of correct formulas and procedures. This error indicates that the student did not fully grasp the relationships between the concepts taught and their applications in mathematical problems. This finding aligns with Naisunis et al. (2018), who found that lack of conceptual understanding can lead to the inability to plan effective solutions. Hence, more structured teaching on problem-solving steps and practice problems focused on procedural understanding is highly necessary.

3. **Errors in Solving the Problem**

The problem-solving stage is where the most errors occurred. Sixteen students made mistakes at this stage, particularly in applying the concept of derivatives. For example, student TF07 misunderstood the use of derivatives in determining the monotonic interval of a function. This error occurred due to a lack of understanding of the fundamental concept of derivatives and its application in function intervals. This type of error is highly relevant, as it shows that even if students understand the basic concept, they may struggle to apply it in more complex problems. This highlights the importance of deep conceptual understanding and repeated practice in applying learned concepts. Additionally, as stated by Setiyani et al. (2020), errors at this stage also reflect a lack of systematic and logical thinking skills when tackling math problems.

4. **Errors in Rechecking**

Rechecking is a crucial step in ensuring that the final answer is correct. However, interviews with students TF18 and TF20 revealed that none of the students rechecked their answers. A primary reason for this was limited time, as students were still focused on completing other problems. Moreover, a lack of habit in reviewing their work also contributed to this issue. This finding highlights the need to instill the habit of rechecking answers, especially in problems that require careful step-by-step solutions. Teachers should emphasize the importance of allocating time for rechecking and provide exercises that develop students' ability to evaluate their own solutions.

The results of this study show that the errors made by students in solving problems on derivatives of algebraic functions are highly varied, ranging from misunderstanding the problem, poor planning of the solution, to mistakes during the problem-solving process and rechecking. The implication of these findings is the need for a more focused instructional approach that strengthens students' understanding of fundamental concepts, promotes more systematic solution planning, and encourages the habit of reviewing their work.

Teachers need to gain deeper insights into students' thought processes and provide constructive feedback so that students can clearly understand where they made mistakes and how to correct them. In addition, the time constraints frequently reported by students indicate the need for more efficient time management during practice and assessment to ensure that students can complete problems more effectively.

CONCLUSION

Based on the research results, it can be concluded that the errors made by students in solving problems related to the derivative function material include: 1) errors in the problem comprehension stage, errors in planning the solution, errors in solving the problem, and errors in the rechecking stage. 2) The types of

errors found include factual errors, conceptual errors, principle errors, and operational errors. 3) The solution suggested by the researcher is for students to get used to rechecking their work. This can be reinforced by strengthening fundamental concepts, so that students can better manage their time when solving problems.

Based on these conclusions, the researcher suggests that in teaching and learning activities about derivatives of functions, more attention should be given to the basic understanding of derivatives and functions. It is hoped that fundamental errors can be minimized before students study more advanced conceptual material

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