
ANALYSIS OF STUDENTS' MATHEMATICS PROBLEM-SOLVING ABILITY: A CASE ON DERIVATIVE FUNCTION

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ABSTRACT

Mathematical problem-solving ability is a basic competency that supports conceptual understanding and application of calculus concepts, especially derivatives, at the high school level. However, many students still experience difficulties in translating contextual problems into appropriate mathematical models and applying derivative concepts effectively. This study aims to investigate the mathematical problem-solving abilities of 12th-grade students on the topic of derivative functions. This study used a qualitative descriptive approach to gain an in-depth understanding of students' problem-solving processes. Participants consisted of 12th-grade students from SMA IT Al-Husnayain, who were purposively selected to represent high, medium, and low levels of problem-solving ability. Data were collected through a contextual essay test on derivative applications and semi-structured interviews. Test items were designed based on Polya's problem-solving indicators: understanding the problem, constructing a mathematical model, applying a solution strategy, and reviewing the results. Data analysis was conducted by examining students' written answers, triangulating with interview data, and categorizing students according to demonstrated abilities. The results showed that students in the high-ability category were able to systematically apply derivative concepts, construct accurate models, and verify their solutions. Students with medium abilities generally understood the basic concepts but made procedural errors and tended to neglect formal verification. Meanwhile, low-ability students experienced significant difficulties in understanding the problem context, constructing correct mathematical models, and interpreting the results. In conclusion, students' problem-solving abilities in derivatives varied significantly across ability levels. These findings highlight the importance of a problem-based learning approach that emphasizes conceptual understanding, modeling skills, and reflective verification to enhance students' mathematical problem-solving competencies.

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INTRODUCTION

Education plays a pivotal role in shaping human capital and fostering national development, particularly in developing countries such as Indonesia. Beyond its function as a medium for knowledge transmission, education is expected to cultivate higher-order thinking skills, including critical thinking and problem-solving abilities, which are essential for addressing the complexities of the 21st century (Sastrawijaya, 1991; Ministry of Education and Culture [MoEC], 2016; Partnership for 21st Century Skills, 2019). In this context, mathematics occupies a strategic position due to its capacity to develop logical, analytical, and systematic reasoning (National Council of Teachers of Mathematics [NCTM], 2000). Therefore, mathematics education should not merely emphasize procedural fluency but also promote meaningful understanding and the development of problem-solving competencies (Kilpatrick et al., 2001).

Mathematical problem-solving ability is widely recognized as a core competency in mathematics learning. It enables students to interpret problems, construct mathematical models, and apply appropriate strategies to obtain solutions (Polya, 1973; Schoenfeld, 1985). At the senior high school level, derivatives represent a fundamental topic in calculus that requires both conceptual understanding and procedural fluency. Derivatives are not only computational tools but also powerful instruments for analyzing rates of change and solving optimization problems in real-life contexts (Stewart, 2016; Siregar & Siregar, 2025). Furthermore, derivative understanding involves multiple representations—symbolic, graphical, and verbal which often become sources of students' learning difficulties (Zandieh, 2000).

Despite its importance, empirical evidence indicates that students' mathematical problem-solving abilities in Indonesia remain relatively low. The Programme for International Student Assessment (PISA) 2022 reported that Indonesia scored 366 in mathematics, significantly below the OECD average of 472, with most students performing only at basic proficiency levels and struggling with non-routine problem-solving tasks (OECD, 2023). Similarly, results from the Trends in International Mathematics and Science Study (TIMSS) highlight that Indonesian students' mathematical reasoning abilities are still comparatively weak (Mullis et al., 2020). At the national level, studies consistently report that students perceive mathematics as difficult and abstract, which negatively affects their engagement and achievement (Mustangin et al., 2019; Julaeha et al., 2020). Moreover, students tend to rely on memorization and procedural approaches rather than conceptual understanding, limiting their ability to solve contextual problems effectively (Hadi et al., 2023; Widodo et al., 2021).

These challenges become more pronounced in learning derivatives. Previous studies reveal that while students are capable of performing routine differentiation procedures, they encounter significant difficulties when applying derivative concepts to contextual or word problems (Tall, 1993; Orton, 1983). For instance, Syaputra et al. (2024) found that students frequently make errors across all stages of problem-solving, with the highest error rate occurring in the *looking back* stage, indicating weak metacognitive awareness. Other studies suggest that these difficulties stem from misconceptions about derivative concepts, insufficient conceptual understanding, and limited exposure to higher-order thinking tasks (Zandieh, 2000; Hiebert & Grouws, 2007). These findings highlight a persistent gap between procedural proficiency and conceptual understanding in mathematics learning.

Although a growing body of research has examined students' mathematical problem-solving abilities, most studies tend to focus on final outcomes or types of errors rather than investigating the underlying cognitive processes involved in problem-solving (Schoenfeld, 1985; Lester, 2013). Furthermore, studies that specifically analyze problem-solving abilities in derivative topics using a structured framework such as Polya's stages particularly across different ability

levels remain limited. This indicates a lack of comprehensive understanding of how students engage in each phase of problem-solving, including understanding the problem, devising a plan, carrying out the plan, and reflecting on the solution.

Addressing this gap is crucial, as an in-depth analysis of students' problem-solving processes can provide valuable insights into their thinking patterns and learning difficulties. Therefore, this study employs Polya's problem-solving framework as an analytical lens to examine students' mathematical problem-solving abilities in derivative topics. This approach allows for a systematic evaluation of students' performance at each stage of problem-solving, offering a more comprehensive perspective compared to outcome-based analyses.

The novelty of this study lies in its focus on analyzing students' problem-solving processes in derivatives based on ability categories using Polya's stages as a comprehensive framework. Unlike previous studies that primarily emphasize error identification, this study provides an in-depth exploration of students' cognitive processes at each stage, thereby contributing to the development of more effective instructional strategies in mathematics education.

Accordingly, the primary objective of this study is to analyze the mathematical problem-solving abilities of Grade XII students in derivative topics based on Polya's stages. Additionally, this study aims to identify students' difficulties at each stage and propose pedagogical recommendations to improve the quality of mathematics instruction. The findings are expected to provide valuable insights for educators and contribute to enhancing the effectiveness of mathematics learning at the secondary school level.

METHOD

This study employed a descriptive qualitative approach to explore in depth students' mathematical problem-solving abilities in derivative topics. A qualitative design was chosen because it allows for a detailed analysis of students' thinking processes at each stage of problem-solving rather than merely focusing on final outcomes (Creswell, 2014). The study aimed to describe how students understand problems, plan solutions, execute strategies, and evaluate their answers based on Polya's framework.

The participants of this study were eight Grade XII students from SMA IT Al-Husnayain. These students were selected as initial subjects to represent a range of mathematical abilities. From these eight students, three students were purposively selected to become the main research subjects, representing three levels of mathematical problem-solving ability: high, medium, and low.

The selection process was based on the results of a diagnostic test, which was administered prior to the main data collection. The categorization of students into ability levels was determined using their test scores and performance indicators in solving mathematical problems. The instruments used in this study consisted of:

1. Mathematical problem-solving test

The test consisted of contextual problems on derivatives, designed to measure students' abilities based on Polya's problem-solving stages. The test items were validated by experts to ensure content validity.

2. Semi-structured interview guide

Interviews were conducted to explore students' reasoning processes in greater depth and to clarify their written responses.

3. Documentation

Students' written answers were collected as supporting data for analysis.

The research was conducted through the following steps:

1. Preparation stage
 - a. Developing research instruments (test and interview guide).
 - b. Validating the instruments with experts.
2. Initial data collection
 - a. Administering a diagnostic test to eight students,
 - b. Analyzing test results to classify students into high, medium, and low ability categories.
3. Main data collection
 - a. Selecting three representative students using purposive sampling,
 - b. Administering the main problem-solving test,
 - c. Conducting in-depth interviews with selected students.
4. Data verification
 - a. Applying triangulation techniques by comparing test results and interview data
5. Data organization
 - a. Categorizing data based on Polya's problem-solving stages

Data were analyzed using qualitative data analysis techniques following the steps proposed by Miles, Huberman, and Saldaña (2014), which include:

1. Data Reduction
 Selecting, focusing, and simplifying data obtained from tests and interviews
2. Data Display
 Organizing data into descriptive narratives based on Polya's stages (understanding the problem, devising a plan, carrying out the plan, and looking back)
3. Conclusion Drawing and Verification
 Interpreting the findings to identify patterns in students' problem-solving processes and verifying the consistency of data through triangulation

The analysis focused on identifying students' abilities and difficulties at each stage of Polya's problem-solving process. This approach enabled a comprehensive understanding of students' cognitive processes in solving derivative problems.

RESULTS AND DISCUSSION

Results

The mathematical problem-solving ability test will be grouped into three categories: high, medium, and low.

Table 1. Mathematical Problem-Solving Ability Indicators

Indicator	Description
Understanding the Problem	Identifying important information and completion objectives
Developing Mathematical Models	Translate the problem into the form of an equation or function

Indicator	Description
Implementing Resolution Strategies	Performing analysis procedures and using derivatives
Checking Results	Reassess the accuracy of results and interpretation

Analysis of High-Category Students' Responses

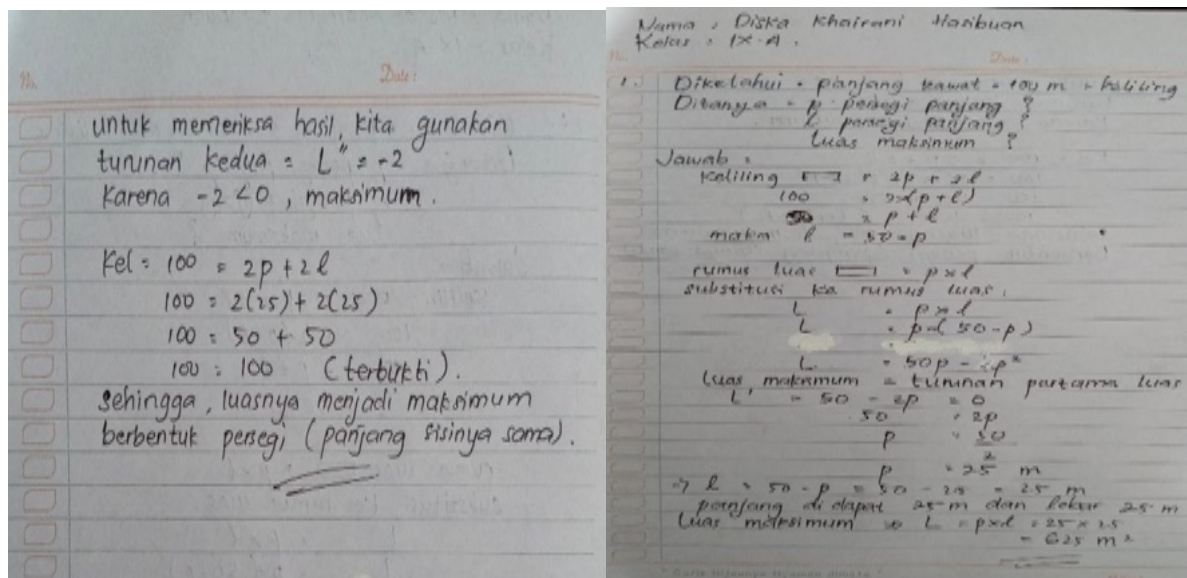


Figure 1. High Problem Solving Ability Students' Answer

Students in the high category demonstrated excellent mastery of derivative concepts and their applications. The analysis revealed the following findings:

1. Understanding the Problem

High-category students were able to extract essential information from the problem, including that the perimeter of the enclosure is 100 meters, the shape is rectangular, and the objective is to determine the maximum area. Furthermore, students restated the information mathematically without errors.

2. Constructing the Mathematical Model

High-category students successfully transformed the perimeter into a constraint equation. They determined that $2p + 2l = 100$, which simplifies to $p + l = 50$. In addition, they correctly linked the constraint to the area function, $L = p \cdot l$. By substituting $l = 50 - p$, students formulated a single-variable function: $L(p) = p(50 - p)$. This indicates that students were able to construct a complete and systematic mathematical model.

3. Solution Strategy

Students correctly derived the first derivative: $L'(p) = 50 - 2p = 0 \Rightarrow p = 25$. Subsequently, they accurately determined the extreme point, obtaining $p = 25$ and $l = 25$ through substitution into the width equation. Thus, they concluded that the maximum area occurs when the shape is a square.

4. Verification and Interpretation

High-category students applied the second derivative test for verification. They evaluated the second derivative and concluded that the critical point corresponds to a maximum value: $L''(p) = -2 < 0$. Furthermore, students rechecked their results by substituting them back

into the perimeter equation and provided an appropriate interpretation, namely that the maximum area is achieved when the enclosure forms a square.

The analysis of interview data confirms that high-category students demonstrate integrated conceptual and procedural knowledge, as well as strong metacognitive awareness. One student stated:

“I first identified that this is an optimization problem. Since the perimeter is fixed, I expressed one variable in terms of another and then maximized the area using derivatives.”

This response indicates that the student possesses a well-developed problem schema and is capable to recognize underlying mathematical structures. The ability to translate a contextual problem into a formal optimization framework reflects advanced conceptual understanding. Another student explained:

“After finding the critical point, I checked the second derivative to make sure it gives a maximum value, not a minimum.”

This response demonstrates metacognitive regulation, particularly in the verification stage. The student not only followed procedural steps but also ensured the correctness of the solution through formal mathematical reasoning.

From a theoretical perspective, these findings are consistent with Polya’s stages of problem-solving, in which high-category students effectively perform all phases: understanding the problem, devising a plan, carrying out the plan, and looking back. Furthermore, their performance reflects relational understanding, characterized by meaningful connections between concepts and procedures.

Overall, the analysis indicates that high-category students possess strong conceptual understanding, high procedural accuracy, well-developed mathematical reasoning, and produce complete, coherent, and verified solutions.

Analysis of Moderate-Category Students’ Responses

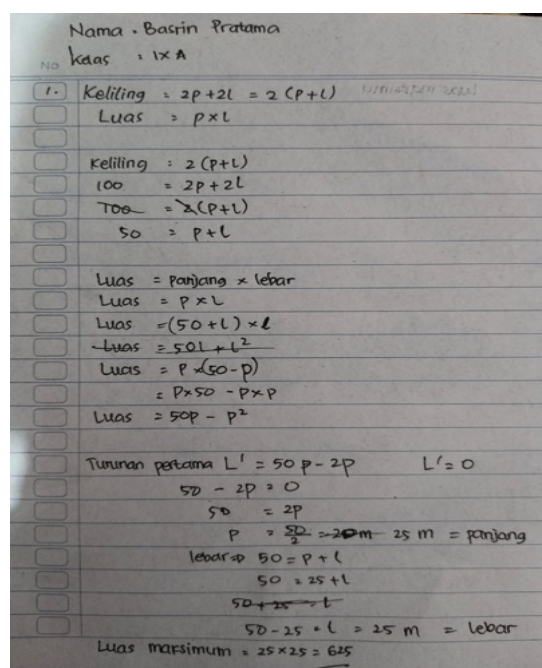


Figure 2. Moderate Problem Solving Ability Students’ Answer

Students in the moderate category demonstrated an understanding of basic concepts but frequently made minor procedural errors.

1. Understanding the Problem

Moderate-category students were able to identify the main information; however, some elements were not completely stated, such as the optimization objective or the constraint in its correct mathematical form at the initial stage.

2. Constructing the Mathematical Model

Students correctly formulated the perimeter equation but initially made an error in substitution when constructing the area function, resulting in a less efficient solution process. This error was later corrected during the solution, leading to:
 $L = p(50 - p)$.

3. Solution Strategy

Students were able to apply derivatives to determine the optimal value; however, minor errors occurred in algebraic manipulation. The first derivative was written correctly, but an arithmetic error appeared when determining the critical point (initially $p = 20$). After reviewing their work, students corrected the result to $p = 25$, leading to the correct final answer.

4. Verification and Interpretation

Students did not perform a formal verification of their results, such as applying the second derivative test or systematically rechecking their solutions.

Interview results reveal that moderate-category students possess partial conceptual understanding but experience instability in procedural execution and limited metacognitive monitoring. One student stated:

“I knew I had to use derivatives, but I got confused when substituting the variables, so I made a mistake at first.”

Another student mentioned:

“I didn’t check my answer again because I thought it was already correct.”

This statement highlights a lack of metacognitive awareness, particularly in the evaluation stage. The absence of a verification process indicates incomplete engagement with the final stage of problem-solving.

These findings are consistent with prior studies indicating that students at this level tend to rely on instrumental understanding, where procedures are applied without deep conceptual grounding. Within Polya’s framework, moderate-category students generally succeed in the initial stages but are less consistent in performing the “looking back” phase.

Overall, moderate-category students demonstrate a fairly good conceptual understanding and the ability to self-correct. However, their procedural accuracy remains inconsistent, and formal mathematical verification is generally absent.

Analysis of Low-Category Students' Responses

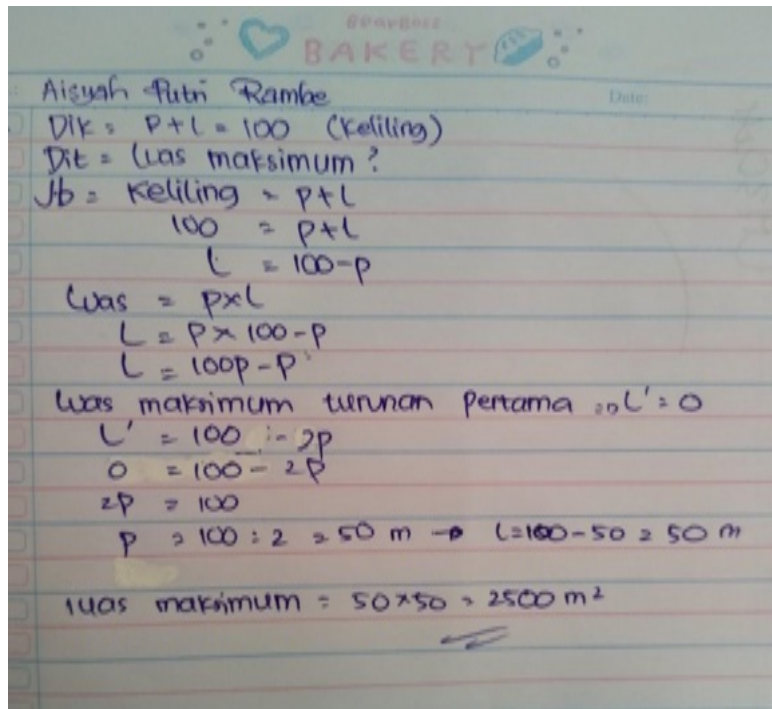


Figure 3. Low Problem Solving Ability Students' Answer

Students in the low category exhibited difficulties in fundamental concepts, particularly in understanding the problem and constructing mathematical models.

1. Understanding the Problem

Low-category students misunderstood the concept of the perimeter of a rectangle, writing $p + l = 100$, indicating that they assumed the perimeter is simply the sum of length and width.

2. Constructing the Mathematical Model

Due to the incorrect formulation of the constraint, the resulting area function was also incorrect: $L = p(100 - p)$. Consequently, the mathematical model constructed by the students was inconsistent with the problem context and could not produce a valid solution.

3. Solution Strategy

Students procedurally computed derivatives correctly; however, the results were irrelevant due to the incorrect initial model. As a result, they obtained $p = 50$ and $l = 50$ and assumed these values were correct without verifying the perimeter condition.

4. Verification and Interpretation

Low-category students did not perform any verification of their final results. They failed to recognize that the calculated perimeter was 200 instead of 100.

Interview data from low-category students reveal fundamental misconceptions and fragmented understanding of mathematical concepts. One student stated:

“I thought the perimeter was just length plus width, so I used that to make the equation.”

Another student expressed:

“I just followed the steps of differentiation that I remembered, even though I wasn’t sure about the formula.”

This response reflects a trial-and-error approach and a reliance on memorized procedures without conceptual understanding. The strategy employed lacks coherence and is not supported by meaningful reasoning.

From a cognitive perspective, these findings indicate deficiencies in mathematical representation and schema construction. Students fail to establish connections between real-world contexts and formal mathematical expressions. This is consistent with existing research suggesting that low-achieving students often struggle to transform verbal problems into symbolic representations.

Overall, the analysis indicates that low-category students require more intensive guidance in understanding fundamental concepts, developing accurate mathematical representations, recognizing relationships between variables, and applying appropriate problem-solving strategies.

The analysis of students categorized by ability level reveals key differences at each stage of problem-solving, namely:

Table 2. Differences in Students' Mathematical Problem-Solving Abilities

Problem Solving Stage	High	Medium	Low
Understanding the problem	Very good	Fair	Weak
Building a model	Correct	Quite correct	Wrong / not correct
Completing the strategy	Accurate and coherent	There are procedural errors	Not accurate
Checking results	Done and correct	Not formal	Not done
Understanding the concept of derivatives	Deep	Moderate	Low

Table 2 illustrates clear distinctions in students’ mathematical problem-solving abilities across high, moderate, and low categories at each stage of the problem-solving process. High-ability students consistently demonstrate very strong performance, characterized by accurate problem comprehension, correct and systematic construction of mathematical models, coherent and precise execution of solution strategies, and thorough verification of results, all of which are supported by a deep understanding of derivative concepts. In contrast, moderate-ability students exhibit a fairly good level of understanding, particularly in identifying problem information and constructing models; however, their performance is often hindered by procedural inaccuracies and a lack of formal verification, reflecting partial conceptual understanding and limited metacognitive control. Meanwhile, low-ability students encounter substantial difficulties across nearly all stages, especially in understanding the problem and formulating appropriate mathematical models, which subsequently leads to inaccurate solution strategies and the absence of result verification. These limitations are closely associated with weak conceptual understanding of derivatives. Overall, the findings suggest that mathematical problem-solving ability is not solely dependent on procedural proficiency but is fundamentally influenced by the integration of conceptual understanding, representational competence, and metacognitive awareness.

Discussions

This study was designed to analyze how Grade XII students apply derivative concepts in solving contextual optimization problems, with a particular focus on Polya's problem-solving stages. The findings indicate that students' mathematical problem-solving ability in derivative function material is not solely determined by procedural skills in differentiation, but is strongly influenced by conceptual understanding as well as the ability to construct and interpret mathematical models (Siregar & Siregar, 2025). These results are consistent with previous studies showing that students tend to perform well on low- to moderate-level derivative problems due to routine practice and familiarity with basic procedures, yet experience a significant decline in performance when confronted with more complex problems, primarily due to limited conceptual understanding. Thus, both studies highlight a persistent gap between procedural proficiency and conceptual understanding. However, this study extends prior research by demonstrating that the integration of conceptual understanding, representational competence, and mathematical modeling plays a crucial role in successfully solving contextual problems, particularly across Polya's problem-solving stages. This finding reinforces the view that problem-solving in calculus requires the integration of conceptual, procedural, and representational knowledge, rather than mere mechanical application of differentiation rules (Hendriana & Utari, 2017).

This study confirms that students exhibit significant differences in problem-solving profiles across high, medium, and low ability categories. High-ability students demonstrate an integrated conceptual understanding of derivatives as tools for optimization, as reflected in their ability to relate constraints, construct single-variable function models, and accurately interpret extreme values. These findings contrast with previous studies indicating that students' mathematical understanding of algebraic function derivatives remains relatively low, as evidenced by frequent conceptual and procedural errors, particularly in selecting appropriate operations and classifying mathematical objects (Mulyani & Siregar, 2025). This comparison suggests that weak conceptual understanding leads to students' inability to construct appropriate models and apply procedures correctly. Therefore, it can be concluded that strong conceptual understanding is a key factor in successful problem-solving, as it enables students to systematically integrate concepts and procedures, whereas deficiencies in this aspect tend to result in recurring errors in the mathematical problem-solving process.

From a scientific perspective, the difficulties observed among medium- and low-ability students can be interpreted as weaknesses in conceptual transfer and mathematical representation. Medium-ability students generally understood the purpose of differentiation in optimization problems, but their solutions were often disrupted by algebraic inaccuracies and the absence of formal verification. This indicates that while conceptual awareness exists, procedural fluency and metacognitive control remain unstable. Similar findings have been reported by Firda et al. (2023), who noted that students often fail to consistently implement problem-solving strategies even when they understand the underlying concepts (Astuti et al., 2025).

Low-ability students tend to make errors at the early stages of problem-solving due to misconceptions of fundamental concepts, such as the relationship between perimeter and area, resulting in incorrect mathematical models and ineffective solution processes. This finding is consistent with studies indicating that weak conceptual understanding and representational skills hinder students' ability to translate problems into mathematical expressions. In contrast, research on Autograph-assisted Think Pair Share (Auto-TPS) shows that technology-supported collaborative learning can significantly improve students' problem-solving abilities through visualization and peer interaction (Nida Siregar et al., 2024). Therefore, while this study highlights conceptual weaknesses as the main barrier, the comparison study suggests that

innovative, technology-based instructional strategies can effectively address these limitations and enhance students' mathematical problem-solving skills.

The findings of this study indicate that students tend to focus on symbolic manipulation while neglecting model construction and result interpretation, particularly in derivative topics, and still show weaknesses in the verification stage due to a lack of reflective thinking habits. In addition, misconceptions in prerequisite concepts such as area and perimeter have been shown to weaken students' ability to solve contextual problems (Firmansyah et al., 2025). When compared with studies on contextual approach-based electronic modules, it is evident that interactive learning supported by cognitive scaffolding can significantly improve students' self-efficacy and problem-solving abilities. Therefore, both studies emphasize the importance of conceptual understanding; however, the comparative study highlights that technology-based and context-oriented learning media can serve as effective solutions to enhance students' representational skills, mathematical modeling, and reflective thinking habits in problem-solving.

Taken together, the discussion underscores that mastery of derivative techniques alone does not guarantee successful problem-solving in real-world contexts. Instructional approaches that emphasize problem-based learning, mathematical modeling, and guided reflection are therefore essential to foster deeper understanding and transferable problem-solving skills (Adeoye & Jimoh, 2023). By engaging students in constructing meaning from contextual problems and encouraging systematic verification, mathematics learning can better support the development of robust problem-solving competencies in derivative function material.

CONCLUSION

This study aimed to analyze Grade XII students' mathematical problem-solving abilities in derivative topics based on Polya's stages. The findings reveal clear differences across ability levels. High-ability students demonstrate integrated conceptual understanding, accurate mathematical modeling, coherent solution strategies, and consistent verification, indicating strong metacognitive awareness. Moderate-ability students show partial conceptual understanding but experience procedural inconsistencies and tend to neglect formal verification. In contrast, low-ability students face fundamental difficulties in understanding problems and constructing appropriate mathematical models, which leads to inaccurate solutions despite sometimes correct procedural steps. These results indicate that mathematical problem-solving ability in derivatives is not solely determined by procedural skills, but is strongly influenced by conceptual understanding, representational competence, and metacognitive control.

Based on these findings, future research is recommended to involve larger and more diverse samples to enhance generalizability, as well as to incorporate quantitative approaches for stronger empirical validation. In addition, further studies should investigate the effectiveness of instructional interventions, such as problem-based learning or technology-assisted learning (e.g., GeoGebra), in improving students' conceptual understanding and problem-solving abilities in calculus contexts.

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REFERENCES

- Astuti, S. A. B., Siregar, R. N., & Rangkuti, R. K. (2025). Analysis of Students' Mathematical Critical Thinking in Solving Function Derivative Problems based on Gender Differences. (*JIML*) *JOURNAL OF INNOVATIVE MATHEMATICS LEARNING*, 8(1), 188–199. <https://doi.org/10.22460/jiml.v8i1.27166>
- Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). SAGE Publications.
- Firmansyah, F., Mujib, A., Siregar, R. N., & Mathelinea, D. (2025). Electronic Modul Contextual Learning In Mathematics: Analizing Its Impact On Student Self-Efficacy And Problem Solving Abilities. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, 9(2), 495–512. <https://doi.org/10.22437/jiituj.v9i2.42554>
- Hadi, S., Nurhayati, N., & Prasetyo, B. (2023). Analysis of students' difficulties in solving mathematical problems. *Journal on Mathematics Education*, 14(2), 155–168. <https://doi.org/10.22342/jme.v14i2>.
- Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 371–404). Information Age Publishing.
- Julaeha, S., Putri, R. I. I., & Zulkardi. (2020). Students' difficulties in learning mathematics. *Journal of Physics: Conference Series*, 1480(1), 012045. <https://doi.org/10.1088/1742-6596/1480/1/012045>
- Kementerian Pendidikan dan Kebudayaan. (2016). *Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 21 Tahun 2016 tentang Standar Isi Pendidikan Dasar dan Menengah*. Kemendikbud.
- Kilpatrick, J., Swafford, J., & Findell, B. (2001). *Adding it up: Helping children learn mathematics*. National Academy Press.
- Lester, F. K. (2013). Thoughts about research on mathematical problem-solving instruction. *The Mathematics Enthusiast*, 10(1–2), 245–278.
- Ministry of Education and Culture. (2016). *Regulation of the Minister of Education and Culture No. 21 of 2016*. MoEC.
- Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2020). *TIMSS 2019 international results in mathematics and science*. International Association for the Evaluation of Educational Achievement (IEA).
- Mulyani, S., & Siregar, R. N. (2025). Analysis of Students' Mathematical Understanding of Derivatives Algebraic Function on Islamic Boarding High School. (*JIML*) *JOURNAL OF INNOVATIVE MATHEMATICS LEARNING*, 8(1), 173–187. <https://doi.org/10.22460/jiml.v8i1.27159>

- Mustangin, M., Kusumah, Y. S., & Sabandar, J. (2019). Students' perception toward mathematics learning. *Journal of Physics: Conference Series*, 1157(3), 032123. <https://doi.org/10.1088/1742-6596/1157/3/032123>
- National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. NCTM.
- Nida Siregar, R., Suryadi, D., Prabawanto, S., & . A. M. (2024). Improving Mathematical Problem-Solving Abilities through Think Pair Share Learning Using Autograph. *KnE Social Sciences*. <https://doi.org/10.18502/kss.v9i8.15583>
- OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. <https://doi.org/10.1787/53f23881-en>
- Orton, A. (1983). Students' understanding of differentiation. *Educational Studies in Mathematics*, 14(3), 235–250. <https://doi.org/10.1007/BF00410540>
- Partnership for 21st Century Skills. (2019). *Framework for 21st century learning*. P21.
- Polya, G. (1973). *How to solve it: A new aspect of mathematical method* (2nd ed.). Princeton University Press.
- Sastrawijaya, T. (1991). *Pengantar pendidikan*. Rineka Cipta.
- Schoenfeld, A. H. (1985). *Mathematical problem solving*. Academic Press.
- Siregar, E., & Siregar, N. (2025). Application of derivatives in contextual problem solving. *Journal of Advanced Mathematics Education*, 5(1), 12–25.
- Siregar, R., & Siregar, R. N. (2025). Analysis of Students' Mathematical Problem-Solving Ability on Senior High School – Case on Function Derivative Material. (*JIML*) *JOURNAL OF INNOVATIVE MATHEMATICS LEARNING*, 8(1), 148–159. <https://doi.org/10.22460/jiml.v8i1.27134>
- Stewart, J. (2016). *Calculus: Early transcendentals* (8th ed.). Cengage Learning.
- Syaputra, R., Ananda, R., & Fitriani, D. (2024). Error analysis in derivative problem-solving. *Journal of Mathematics Learning*, 8(2), 101–115.
- Tall, D. (1993). Students' difficulties in calculus. In *Proceedings of ICME Conference*.
- Widodo, A., Nurhayati, N., & Rahmawati, D. (2021). Students' conceptual understanding in mathematics learning. *International Journal of Instruction*, 14(3), 567–582. <https://doi.org/10.29333/iji.2021.14333a>
- Zandieh, M. (2000). A theoretical framework for analyzing student understanding of the concept of derivative. *Research in Collegiate Mathematics Education*, 4, 103–127.