(JIML) JOURNAL OF INNOVATIVE MATHEMATICS LEARNING
Volume 8, No. 4, December 2025

P-ISSN 2621-4733
E-ISSN 2621-4741

https://dx.doi.org/10.22460/jiml.v8i4.p30089

APPLICATION OF DISCOVERY LEARNING MODEL TO IMPROVE STUDENTS' CONCEPTUAL UNDERSTANDING ON ALGEBRAIC FUNCTION DERIVATIVES

Palwina Machrani[1], Rahmat Badawi[2], Rama Nida Siregar[3]
[1]UIN Syahada Padangsidimpuan, Jl. T. Rizal Nurdin, Padangsidimpuan, Indonesia.
wiwinsiregar82@gmail.com
[2]UIN Syahada Padangsidimpuan, Jl. T. Rizal Nurdin, Padangsidimpuan, Indonesia.
rahmadbadawi123@gmail.com
[3]UIN Syahada Padangsidimpuan, Jl. T. Rizal Nurdin, Padangsidimpuan, Indonesia.
ramanidasiregar575@uinsyahada.ac.id

ARTICLE INFO

Article history:

Received Nov 25, 2025
Revised Nov 29, 2025
Accepted Dec 14, 2025

Keywords:

Conceptual Understanding
Algebraic Function Derivatives
Discovery Learning
Senior High School

ABSTRACT

Understanding the derivative of algebraic functions remains challenging for many students, particularly in linking fundamental concepts such as limits, rates of change, and the geometric interpretation of tangent slopes. These persistent difficulties indicate that conventional instruction has not sufficiently supported students in constructing deep conceptual knowledge. This study aims to analyze the effect of the Discovery Learning model on improving students' conceptual understanding of algebraic function derivatives. A quasi-experimental method with a Nonequivalent Control Group Design was employed, involving two Grade XII classes at SMA Negeri 1 Batangtoru. The experimental class received instruction using Discovery Learning, while the control class received direct instruction. Data were obtained through conceptual understanding tests, student activity observations, and teacher observations. The implementation of Discovery Learning followed stages of stimulation, problem identification, data collection, verification, and generalization, enabling students to explore derivative concepts through graphical, numerical, and symbolic representations. The results show that the experimental class achieved a higher mean posttest score (82.6) than the control class (73.3). A t-test yielded a significance value of 0.001, indicating a significant difference between the two groups. These findings demonstrate that Discovery Learning enhances students' conceptual understanding by promoting active exploration, reasoning, and pattern recognition. In conclusion, Discovery Learning is effective for teaching derivatives of algebraic functions and offers strong potential to support concept-based mathematics instruction at the secondary school level.

Corresponding Author:
Palwina Machrani,
Masters Program in Mathematics Education,
UIN Syekh Ali Hasan Ahmad Addary Padangsidimpuan,
Jl. T. Rizal Nurdin, Padangsidimpuan, Indonesia
Email: wiwinsiregar82@gmail.com

How to Cite:

Machrani, P., Badawi, R., & Siregar, R.N. (2025). Application of Discovery Learning Model to Improve Students' Conceptual Understanding on Algebraic Function Derivatives. *JIML*, 8(4), 839-849.

INTRODUCTION

The derivative of an algebraic function is an essential topic in calculus, serving as a foundation for various branches of applied mathematics (Astuti et al., 2025; Mulyani & Siregar, 2025). The concept of the derivative is not only used to determine the rate of change of a function but is also a fundamental element in graphical analysis, optimization, and modeling of various scientific phenomena (Siregar & Siregar, 2025). Therefore, a thorough understanding of the concept of the derivative is crucial in high school mathematics learning. However, the reality in the field shows that students often struggle to develop a comprehensive conceptual understanding. They tend to focus solely on procedural algorithms and formula memorization, without understanding the relationship between the derivative and the limit as its basic definition, or the geometric interpretation of the slope of the tangent line.

Research shows that most students incorrectly connect the concept of the limit with the meaning of the derivative, leading to recurring misconceptions about determining the rate of change (Siregar & Siregar, 2025). Similar findings were reported, who found that over 60% of students still interpret the derivative as a purely mechanical algebraic process. Students' inability to grasp this concept comprehensively is also caused by a learning design that tends to be one-way, where the teacher dominates the explanation and students become passive recipients of information (Legi Adilawati et al., 2025). This type of learning doesn't allow students to build understanding through exploration, discussion, or independent reasoning.

On the other hand, various studies have shown that mastery of mathematical concepts, including derivatives, is strongly influenced by students' active involvement in the learning process (Rodríguez-Nieto & Moll, 2025). However, traditional learning approaches often fail to facilitate this. Research, for example, shows that conventional learning is ineffective in improving critical thinking skills and conceptual understanding (Hafeez, 2021). In the context of calculus, this becomes even more of a barrier because material such as limits, derivatives, or integrals requires high-level representation, generalization, and abstraction (Sakdiah & Siregar, 2025).

To address this challenge, various innovative learning models have been proposed. One widely recommended model is Discovery Learning, a learning model that positions students as subjects who actively discover concepts themselves through simple scientific processes. Bruner (1961) explained that knowledge discovered by students is stored longer in long-term memory and is easier to apply in new situations (Sweller, 2021). This basic concept is then applied in modern mathematics education as a strategy to improve conceptual understanding.

Empirical support for the effectiveness of Discovery Learning is quite strong. Research found that students learning with this model had higher conceptual abilities than students learning with conventional learning (Nurhidayat et al., 2023). Another study showed that Discovery Learning not only improves conceptual understanding but also increases motivation, self-confidence, and learning independence (Kurino et al., 2024). A meta-analysis conducted even concluded that this model has a significant and stable effect on conceptual understanding in more than 30 studies across educational levels (Pacaci et al., 2024).

Furthermore, various studies related to calculus also support the argument that Discovery Learning is highly relevant for application to materials requiring in-depth conceptual understanding (Tong et al., 2022). Next, demonstrated that Discovery Learning, supported by worksheets (LKPD), can improve understanding of integral concepts. Found that HOTS-based Discovery Learning forces students to think analytically and evaluatively (Huda & Amanu, 2023). Added that guided discovery combined with blended learning effectively improves understanding of mathematical concepts (Indrapangastuti et al., 2021). This further demonstrates that discovery-based models are highly suitable for use in calculus, including derivatives of algebraic functions.

However, research specifically examining the effectiveness of Discovery Learning on derivatives of algebraic functions is relatively limited. Most previous studies have focused on other topics such as integrals, limits, or general understanding of mathematical concepts. For example, observations demonstrate the effectiveness of this model for understanding mathematical concepts, but do not provide in-depth details regarding the characteristics of derivatives (Feudel & Biehler, 2021). This research gap indicates a research gap, namely the need for focused empirical studies that directly examine the impact of Discovery Learning on understanding the concept of algebraic function derivatives, including how the discovery stages students go through can reduce misconceptions.

Furthermore, studies on the contribution of each Discovery Learning stage to reducing misconceptions are still rare in the literature. Yet, one of the important scientific merits of this research is assessing how the stages of stimulation, identification, data collection, verification, and generalization can form a more structured understanding of the material on derivatives, which theoretically strongly supports the development of higher-order thinking.

Considering the theoretical background, empirical findings, and these research gaps, this study is relevant and important. This research provides novelty because it specifically analyzes the effectiveness of the Discovery Learning model on algebraic function derivatives, supported by empirical data comparing learning outcomes between experimental and control classes. Therefore, the purpose of this study is to analyze the influence of the Discovery Learning model on students' conceptual understanding of algebraic function derivatives in grade XII students at SMA Negeri 1 Batangtoru.

METHOD

This study employed a quasi-experimental method with a Nonequivalent Control Group Design, an experimental design widely used in educational research when full randomization of samples is not possible (Gopalan et al., 2020; Gribbons & Herman, 1996; Krishnan, 2019). This design involves two groups with similar characteristics but not randomized, each given a different treatment, measured through a pretest and posttest. The experimental class received the treatment through the application of the Discovery Learning model, while the control class received direct instruction. This design provided an opportunity to compare changes in ability more objectively because both groups were tested before and after the treatment, and allowed for evaluation of improvements in conceptual understanding based on differences in learning outcomes.

The study was conducted at SMA Negeri 1 Batangtoru in the odd semester of the 2024/2025 academic year, with a population of all 12th grade Mathematics and Natural Sciences students. Sampling was conducted using a purposive sampling technique, as class selection was based on equivalence in students' initial abilities and compatibility with subject teacher schedules. Two classes were selected as samples: class XII MIPA 1 as the experimental class and class XII MIPA 2 as the control class, each consisting of 32 students, resulting in a total sample size of 64 students. The independent variable in this study was the Discovery Learning model, while the dependent variable was understanding of the concept of the derivative of algebraic functions. The Discovery Learning model was chosen because of its effectiveness in encouraging independent concept construction through exploration, data processing, and generalization (Bruner, 1961; Mayer, 2004), while direct instruction was used as a comparison because it is an established method and widely used in mathematics classes.

The research stages were carried out sequentially to ensure replication. In the preparation stage, the researchers developed learning materials for the experimental class by referring to the Discovery Learning syntax: stimulation, problem identification, data collection, data processing, verification, and generalization, as referenced in the classic literature (Hermann, 1969). For the control class, researchers developed a direct learning tool following standard steps commonly used in educational experimental research: apperception, presentation of material, examples, structured exercises, and evaluation (McKeachie, 2006). All developed instruments were validated by three mathematics education experts to ensure content adequacy, then pilot-tested to obtain information on reliability, discriminatory power, and problem difficulty. The testing procedure followed standards commonly used in educational research and will not be repeated in detail here.

The implementation phase lasted four meetings (4 x 90 minutes) in each class. In the experimental class, learning was conducted through stimulating activities, presenting contextual problems related to the rate of change of a function, followed by student problem identification. Students then collected data by exploring function graphs, value tables, and limit representations, which were then processed to discover patterns of relationships between changes in function values and the concept of derivatives. Afterward, students verified the results through mathematical procedures and, in the final stage, developed generalizations in the form of rules for the derivative of algebraic functions. In contrast, in the control class, learning was delivered using lecture methods, direct concept explanations, examples, and exercises without exploration or independent discovery activities. The measurement phase involved administering a pretest before the treatment to determine students' initial abilities and a posttest after the treatment to measure improvements in conceptual understanding. During the learning process, observations of student and teacher activities were recorded using observation sheets to ensure the treatment was implemented as designed.

The research instruments consisted of three types. First, a conceptual understanding test containing five descriptive questions developed based on conceptual ability indicators according to NCTM (2000), namely the ability to link concepts, restate, and classify mathematical objects according to derived properties. This test underwent expert validation and reliability testing using Cronbach's Alpha to ensure the instrument's internal consistency (Hekimoglu & Sloan, 2005). Second, a student activity observation sheet included indicators of active discussion, exploration skills, verification processes, and inference skills, which refer to the characteristics of discovery-based learning. Third, a teacher observation sheet was designed to assess the implementation of Discovery Learning syntax, such as stimulation, discovery facilitation, reinforcement, and reflection on learning.

The dependent variable indicators used in this study include three main indicators of mathematical concept understanding as recommended by NCTM (2000). First, the ability to connect concepts, namely students' ability to relate the meaning of limit, rate of change, and slope of a tangent line to the concept of derivative. Second, the ability to restate concepts, namely students' ability to explain the definition of a derivative, describe the symbolic meaning of $f'(x)$, and interpret the relationship between graphical, numerical, and analytical representations. Third, the ability to classify mathematical objects based on their properties, namely students' ability to distinguish types of algebraic functions and their derivative rules and apply the properties of derivatives conceptually. These indicators were formulated into a question grid that guided the development of the pretest and posttest instruments.

Data analysis was conducted through several stages until answers to the research questions were obtained. First, the pretest results were analyzed using initial equivalence tests (normality test, homogeneity of variance test, and t-test of equivalence) to ensure that the initial abilities of the two classes did not differ significantly. Second, posttest scores were analyzed to see the improvement in conceptual understanding in each group through the calculation of the average value, percentage of completion, and normalized gain (Hekimoglu & Sloan, 2005) to assess relative improvement. Third, the comparison of improvement between the experimental class and the control class was analyzed using an independent t-test with a significance level of 0.05 to determine whether there was a difference in the improvement in conceptual understanding after the application of the student discovery model through Discovery Learning. Fourth, observation data were analyzed descriptively to assess the consistency of the treatment implementation. The results of the quantitative and descriptive analysis were then interpreted in an integrative manner to answer the research question regarding the effectiveness of the Discovery Learning model in improving the understanding of the concept of derivatives of algebraic functions.

RESULTS AND DISCUSSION

Results

The results of this study indicate clear differences in students' conceptual understanding between the experimental class that received Discovery Learning and the control class that received direct instruction. The descriptive statistics of pretest and posttest scores are presented in Tables 1 and 2.

Table 1. Pretest Mean Scores

Class	Mean	SD
Experimental	42.1	8.4
Control	41.7	7.9

Table 2. Posttest Mean Scores

Class	Mean	SD
Experimental	82.6	6.8
Control	73.3	7.1

The independent samples t-test yielded a significance value of 0.001 < 0.05, indicating that there is a statistically significant difference between the posttest results of the two groups. This demonstrates that Discovery Learning has a notable effect on improving students' conceptual understanding of derivative topics in algebraic functions. A comparison of the pretest–posttest means is illustrated in **Figure 1**.

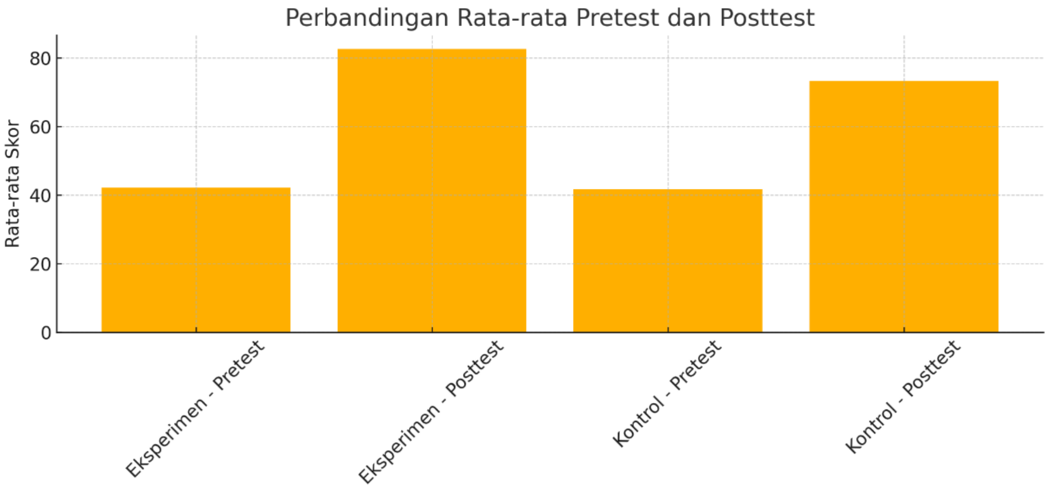

Figure 1. Comparison of Pretest and Posttest Means

The substantial increase in the experimental class from 42.1 to 82.6 shows that students who engaged in the stages of Discovery Learning achieved a higher conceptual mastery than those in the control class. This finding aligns with Bruner's constructivist perspective, which argues that knowledge obtained through self-discovery becomes more meaningful and durable in long-term memory. In this study, phases such as stimulation, problem identification, data collection, verification, and generalization contributed directly to the strengthening of conceptual structures.

At the classroom level, students in the experimental group demonstrated improved ability to identify patterns, relate limit concepts to derivative definitions, and explain derivative concepts as rates of change. For instance, during the data-collection stage, students explored various examples of algebraic functions and investigated the behavior of their graphs, enabling them to connect graphical patterns to the concept of instantaneous rate of change. In contrast, students in the control class tended to rely on procedural rules without a deeper conceptual foundation.

This outcome is consistent with findings reported, who stated that Discovery Learning improves mathematical conceptual understanding (Kristiyajati & Wijaya, 2019). Similar results were observed, emphasizing that Discovery Learning not only enhances conceptual mastery but also increases motivation and self-efficacy (Simamora et al., 2019). Furthermore, a meta-analysis confirmed that Discovery Learning produces consistent positive effects on conceptual understanding across educational levels (Kamaluddin & Widjajanti, 2019). Studies also support the effectiveness of Discovery Learning, particularly when combined with HOTS approaches or structured worksheets (Hasnunidah et al., 2024).

Observational data reinforce these quantitative results. Students in the experimental class were more engaged in asking questions, conducting peer discussions, articulating reasoning, and validating answers. This active participation helped them internalize concepts more effectively. The posttest responses show that students in the experimental group were better able to:

1. Explain derivatives as rates of change;
2. Connect the concept of derivatives with limits;
3. Determine intervals of increasing and decreasing functions with justification;
4. Generalize patterns from multiple examples.

On the other hand, students in the control group predominantly exhibited procedural understanding, such as applying derivative rules without grasping the underlying conceptual meaning. This reinforces the conclusion that Discovery Learning not only enhances learning outcomes but also reduces common misconceptions related to derivatives.

Analysis of Discovery Learning Elements Influencing Understanding of Derivatives of Algebraic Functions

1. Stimulation and Problem Identification

In the initial stage, students are presented with examples of algebraic functions and their graphs. This stimulation encourages students to identify conceptual gaps, such as distinguishing between the average rate of change and the instantaneous rate of change. At this stage, students begin to ask questions about the behavior of functions—an essential step toward understanding the concept of derivatives.

2. Data Collection (Pattern Exploration)

In this stage, students investigate the table of values, the slope of the secant line, and changes in the graph. This exploration helps students observe emerging patterns, particularly the behavior of limits as the interval approaches zero. These patterns form the basis for developing a conceptual definition of the derivative.

3. Data Processing and Verification

Students compare their initial guesses with the formal definition of the derivative through limits. Through the verification process, students correct misconceptions, particularly the tendency to memorize formulas without understanding their meaning. This stage significantly strengthens their ability to explain derivatives as rates of change derived through the process of limits.

4. Generalization (Formulating Rules Independently)

Students formulate rules for derivation as conclusions from observing recurring patterns in various algebraic functions. This generalization process enables students to construct derivation formulas meaningfully, rather than simply memorizing them. As a result, students demonstrate strong performance in tasks requiring conceptual reasoning, such as determining intervals of increasing and decreasing of a function with justification.

The effectiveness of Discovery Learning in this study aligns with previous research showing that DL improves mathematical concept understanding, learning motivation, and reasoning skills. Previous studies also emphasize that DL is most effective when supported by structured problem exploration and collaborative learning activities.

Overall, the findings of this study support previous literature and highlight that Discovery Learning significantly improves conceptual understanding by enabling students to construct knowledge through investigation, verification, and generalization. Therefore, Discovery Learning is highly recommended for teaching derivatives of algebraic functions as well as other mathematical topics requiring deep conceptual reasoning.

Discussions

The central finding of this study is that Discovery Learning substantially improves students' conceptual understanding of derivatives compared to direct instruction. This result strengthens the initial hypothesis that learning models grounded in guided exploration promote deeper conceptualization of abstract mathematical ideas. In line with Bruner's constructivist theory (Bruner, 1961), the process of discovering relationships independently allows students to internalize concepts more meaningfully, supporting stronger long-term retention and easier transfer to new contexts (Hoidn, 2017).

The significance of these findings becomes clearer when considering how Discovery Learning structures the cognitive pathways through which students build conceptual knowledge. The stages of stimulation, problem identification, data gathering, verification, and generalization guide learners to actively test, refine, and reorganize their thinking. Such processes help students form coherent conceptual links such as between limits, instantaneous rate of change, and the derivative which are known to be challenging in conventional instruction (Byerley, 2019). The ability of students in the experimental class to provide mathematical justifications rather than merely execute rules suggests that Discovery Learning facilitates deeper reasoning by engaging students in high-level cognitive operations.

Another scientific insight from this study is the model's capacity to reduce well-documented misconceptions in derivative learning. Students taught through direct instruction tend to rely heavily on memorization of differentiation formulas, often failing to grasp the foundational meaning of the derivative (Mkhatshwa, 2024). Conversely, students engaged in Discovery Learning were able to interpret derivatives as rates of change, analyze intervals of increase and decrease, and generalize patterns across different types of functions. This supports the argument that inquiry-based instruction helps students build relational rather than instrumental understanding (Skemp, 1976), which is crucial in advanced mathematical thinking (Muhammad et al., 2022).

The findings of this study are broadly consistent with previous work indicating that Discovery Learning improves conceptual understanding in mathematics. Reported similar gains, noting that structured discovery activities help students construct conceptual frameworks rather than rely solely on procedural recall (Salcedo et al., 2022). Further found that Discovery Learning elevates motivation and self-efficacy, variables that indirectly support conceptual learning (Ningsih & Jayanti, 2022). A meta-analysis also confirmed that Discovery Learning consistently generates moderate to strong effects on students' conceptual mastery across grade levels and mathematical topics (Palinussa et al., 2023).

However, the present study extends earlier findings by illustrating how Discovery Learning specifically supports the conceptual transition from intuitive graphical reasoning such as interpreting slopes to formal symbolic reasoning in calculus. This nuanced contribution is particularly relevant because students often struggle to integrate multiple representations of the derivative (Siregar & Siregar, 2025). The model's structured inquiry steps appear to function as scaffolds that bridge the gap between intuitive and formal reasoning.

Although consistent with most previous research, this study also reveals slight variations. Unlike studies that emphasize affective gains (e.g., motivation or autonomy), the current findings highlight the strengthening of argumentation and verification processes. This difference may be attributed to the type of learning activities designed in the derivative topic, which requires students to justify claims, analyze patterns, and test hypotheses activities that naturally cultivate argumentative reasoning.

Overall, this study reinforces the view that Discovery Learning is not only an active learning model but a meaning-making framework that systematically guides students through conceptual construction. By enabling learners to negotiate, test, and refine ideas, the model cultivates structured reasoning that is essential for mastering advanced mathematical concepts. For this reason, Discovery Learning is particularly recommended for topics in calculus that demand deep conceptual understanding and multi-representational thinking.

CONCLUSION

This study successfully met its objective of assessing the effectiveness of the Discovery Learning model in improving understanding of the concept of the derivative of algebraic functions. Scientifically, the results show that this discovery-based approach is able to strengthen concept construction through the processes of exploration, verification, and generalization, thus providing a deeper understanding compared to direct learning. These findings not only confirm the effectiveness of the model but also expand existing knowledge regarding how activity design in Discovery Learning can reduce common misconceptions in calculus. The contribution of this study confirms that Discovery Learning not only improves cognitive abilities but also encourages higher-order thinking skills such as mathematical analysis and argumentation, making it worthy of wider application in concept-based mathematics learning. Practically, this study suggests the need for teachers to design structured, discovery-centered learning experiences, utilizing Student Worksheets (LKPD) and investigative activities as a means to guide students in constructing concepts independently. For further development, future research is recommended to try this model on other mathematics materials such as integrals or trigonometry, at different educational levels, and explore its integration with digital technology to strengthen students' conceptual understanding more comprehensively.

ACKNOWLEDGMENTS

Recognize those who helped in the research, especially funding supporter of your research. Include individuals who have assisted you in your study: Advisors, Financial supporter, or may other supporters i.e. Proofreaders, Typists, and Suppliers who may have given materials. The author would like to express sincere gratitude to all individuals and institutions whose support made this research possible. Special appreciation is extended to the academic advisors who provided valuable guidance, constructive feedback, and continuous encouragement throughout the research process. The author also acknowledges the support of SMA Negeri 1 Batangtoru for granting permission to conduct the study and for facilitating access to the school environment, teachers, and students involved as research participants.

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

Byerley, C. (2019). Calculus students' fraction and measure schemes and implications for teaching rate of change functions conceptually. *The Journal of Mathematical Behavior*, *55*, 100694. https://doi.org/10.1016/J.JMATHB.2019.03.001

Feudel, F., & Biehler, R. (2021). Students' Understanding of the Derivative Concept in the Context of Mathematics for Economics. *Journal Fur Mathematik-Didaktik*, *42*(1), 273–305. https://doi.org/10.1007/S13138-020-00174-Z/FIGURES/6

Gopalan, M., Rosinger, K., & Ahn, J. Bin. (2020). Use of Quasi-Experimental Research Designs in Education Research: Growth, Promise, and Challenges. *Review of Research in Education*, *44*(1), 218–243. https://doi.org/10.3102/0091732X20903302

Gribbons, B., & Herman, J. (1996). True and Quasi-Experimental Designs. *Practical Assessment, Research, and Evaluation*, *5*(1). https://doi.org/10.7275/FS4Z-NB61

Hafeez, M. (2021). Systematic Review on Modern Learning Approaches, Critical Thinking Skills and Students Learning Outcomes. *Indonesian Journal of Educational Research and Review*, *4*(1), 167–178. https://doi.org/10.23887/IJERR.V4I1.33192

Hasnunidah, N., Fadhila, S., Yolida, B., Nadya, M., & Maulina, D. (2024). Optimizing Discovery Learning to Enhance HOTS: Why Use Argumentative Worksheets? *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10348–10358. https://doi.org/10.29303/JPPIPA.V10I12.9412

Hekimoglu, S., & Sloan, M. (2005). A Compendium of Views on the NCTM Standards. *Mathematics Educator*, *15*(1), 35–43.

Hermann, G. (1969). Learning by discovery. *Journal of Experimental Education*, *38*(1), 58–72. https://doi.org/10.1080/00220973.1969.11011167;CTYPE:STRING:JOURNAL

Hoidn, S. (2017). Constructivist Foundations and Common Design Principles of Student-Centered Learning Environments. *Student-Centered Learning Environments in Higher Education Classrooms*, 23–103. https://doi.org/10.1057/978-1-349-94941-0_2

Huda, N., & Amanu, B. A. (2023). *Penerapan model discovery learning berbantukan LKPD untuk meningkatkan pemahaman konsep pada materi integral fungsi aljabar*. http://prosiding.senpika.ulm.ac.id/index.php/senpika/article/view/5

Indrapangastuti, D., Dwi Surjono, H., Endri Yanto, B., & Author, C. (2021). Effectiveness of the Blended Learning Model to Improve Students' Achievement of Mathematical Concepts. *Journal of Education and E-Learning Research*, *8*(4), 423–430. https://doi.org/10.20448/journal.509.2021.84.423.430

Kamaluddin, M., & Widjajanti, D. B. (2019). The Impact of Discovery Learning on Students' Mathematics Learning Outcomes. *Journal of Physics: Conference Series*, *1320*(1), 012038. https://doi.org/10.1088/1742-6596/1320/1/012038

Krishnan, P. (2019). A review of the non-equivalent control group post-test-only design. *Nurse Researcher*, *26*(2), 37–40. https://doi.org/10.7748/NR.2018.E1582

Kristiyajati, A., & Wijaya, A. (2019). The Effectiveness of Visualization of Proofs in Learning Mathematics by Using Discovery Learning Viewed from Conceptual Understanding. *Southeast Asian Mathematics Education Journal*, *9*(1), 37–44. https://doi.org/10.46517/SEAMEJ.V9I1.72

Kurino, Y. D., Herman, T., Turmudi, T., Yonanda, D. A., & Haryanti, Y. D. (2024). Enhancing Mathematical Problem-Solving Skills Through Flipped Classrooms and Discovery Learning: A Resilience-Based Approach for Elementary Students. *AL-ISHLAH: Jurnal Pendidikan*, *16*(4), 5399–5408. https://doi.org/10.35445/ALISHLAH.V16I4.6243

Legi Adilawati, F., Siti Nur Atiqoh, K., Eva Musyrifah, dan, Atiqoh, S. N., Musyrifah, dan E., & Kemampuan Berpikir Aljabar Ditinjau dari Gaya Kognitif Siswa, A. (2025). Analisis Kemampuan Berpikir Aljabar Ditinjau dari Gaya Kognitif Siswa. *Euler : Jurnal Ilmiah Matematika, Sains Dan Teknologi*, *13*(2), 238–246. https://doi.org/10.37905/EULER.V13I2.32947

McKeachie, W. J. (2006). Procedures and Techniques of Teaching: A Survey of Experimental Studies. *The American College: A Psychological and Social Interpretation of the Higher Learning.*, 312–364. https://doi.org/10.1037/11181-008

Mkhatshwa, T. P. (2024). Best practices for teaching the concept of the derivative: Lessons from experienced calculus instructors. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(4), em2426. https://doi.org/10.29333/EJMSTE/14380

Muhammad, R. R., Lawson, D., Aslam, F., & Crawford, M. (2022). The Scientific Approach of The Indonesian 2013 Curriculum: A Comparison with Other Active Learning Strategies in Mathematics. *Journal of Research in Science, Mathematics and Technology Education* , *5*(2), 155–171. https://doi.org/10.31756/JRSMTE.523

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

Ningsih, E. L. C., & Jayanti, U. N. A. D. (2022). Discovery Blended Learning in Biology: Its Effectiveness on Self-Efficacy and Student Learning Outcomes in the New Normal Era. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *12*(2), 147–160. https://doi.org/10.30998/FORMATIF.V12I2.13748

Nurhidayat, W., Surahman, E., & Sujarwanto, E. (2023). The Effect of Conceptual Understanding Procedures Learning Model on Students' Higher Level Thinking Skills. *JPI (Jurnal Pendidikan Indonesia)*, *12*(2), 386–394. https://doi.org/10.23887/JPIUNDIKSHA.V12I2.58709

Pacaci, C., Ustun, U., & Ozdemir, O. F. (2024). Effectiveness of conceptual change strategies in science education: A meta-analysis. *Journal of Research in Science Teaching*, *61*(6), 1263–1325. https://doi.org/10.1002/TEA.21887;ISSUE:ISSUE:DOI

Palinussa, A. L., Lakusa, J. S., & Moma, L. (2023). Comparison of Problem-Based Learning and Discovery Learning To Improve Students' Mathematical Critical Thinking Skills.

Formatif: Jurnal Ilmiah Pendidikan MIPA, *13*(1). https://doi.org/10.30998/FORMATIF.V13I1.15205

Rodríguez-Nieto, C. A., & Moll, V. F. (2025). Mathematical connections promoted in multivariable calculus' classes and in problems-solving about vectors, partial and directional derivatives, and applications. *Eurasia Journal of Mathematics, Science and Technology Education*, *21*(4), em2619. https://doi.org/10.29333/EJMSTE/16187

Sakdiah, S., & Siregar, R. N. (2025). Analysis of Students' Errors in Solving Algebraic Function Limit Problems based on Bloom's Taxonomy. *(JIML) Journal of Innovative Mathematics Learning*, *8*(1), 160–172. https://doi.org/10.22460/JIML.V8I1.27152

Salcedo, D., Regan, J., Aebersold, M., Lee, D., Darr, A., Davis, K., & Berrocal, Y. (2022). Frequently Used Conceptual Frameworks and Design Principles for Extended Reality in Health Professions Education. *Medical Science Educator 2022 32:6*, *32*(6), 1587–1595. https://doi.org/10.1007/S40670-022-01620-Y

Simamora, R. E., Saragih, S., & Hasratuddin. (2019). Improving Students' Mathematical Problem Solving Ability and Self-Efficacy through Guided Discovery Learning in Local Culture Context. *International Electronic Journal of Mathematics Education*, *14*(1), 61–72. https://doi.org/10.12973/iejme/3966

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

Sweller, J. (2021). The Role of Evolutionary Psychology in Our Understanding of Human Cognition: Consequences for Cognitive Load Theory and Instructional Procedures. *Educational Psychology Review 2021 34:4*, *34*(4), 2229–2241. https://doi.org/10.1007/S10648-021-09647-0

Tong, D. H., Uyen, B. P., & Ngan, L. K. (2022). The effectiveness of blended learning on students' academic achievement, self-study skills and learning attitudes: A quasi-experiment study in teaching the conventions for coordinates in the plane. *Heliyon*, *8*(12), e12657. https://doi.org/10.1016/j.heliyon.2022.e12657