

Enhancing students' statistical conceptual understanding and learning independence through contextual worksheet-assisted discovery learning

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Abstract

While statistical conceptual understanding and learning independence are crucial in mathematics education, traditional instruction often restricts opportunities for active exploration. Although discovery learning and contextual materials have been examined independently, their integrated impact on these dual outcomes in junior high school statistics remains underexplored. Therefore, this study aimed to investigate the enhancement of students' statistical conceptual understanding and learning independence through Contextual Worksheet-Assisted Discovery Learning. Employing a quantitative pre-experimental (one-group pretest-posttest) design, the research involved 29 ninth-grade students at an Islamic junior high school in Garut Regency, Indonesia. Data collected via conceptual tests and self-report questionnaires were analyzed using paired-sample t-tests, Wilcoxon signed-rank tests, and N-Gain analysis. The results demonstrated a significant improvement in statistical conceptual understanding, with mean scores rising from 64.97 ($SD = 15.37$) to 76.14 ($SD = 19.20$) ($t(28) = -5.239, p < .001$), achieving a moderate N-Gain of 0.41. Concurrently, learning independence significantly increased from 28.34 to 30.41 ($Z = -3.167, p = .002$). These findings suggest that integrating discovery learning with contextual worksheets provides an effective, structured environment that fosters both conceptual exploration and autonomous learning. Although the absence of a control group limits definitive causal claims, this pedagogical approach shows substantial promise for advancing statistical education in secondary schools.

Keywords: contextual student worksheets; discovery learning; learning independence; statistical conceptual understanding

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INTRODUCTION

Statistical literacy and conceptual understanding are fundamental components of mathematics education, requiring students to interpret, evaluate, and communicate data effectively. In junior high school, statistics extends beyond procedural computation; it demands that students comprehend data contexts, interpret various representations, and draw evidence-based conclusions. This emphasis aligns with the Indonesian curriculum's objective to develop mathematical reasoning through meaningful contexts (Kemendikbudristek, 2022) and reflects international standards that position statistical literacy as a vital life competence (Gal, 2002; Watson & Callingham, 2003). However,

cultivating this competence remains challenging when classroom practices disproportionately emphasize rote procedures over conceptual construction.

This pedagogical challenge is particularly evident in Indonesia. The 2022 Program for International Student Assessment (PISA) revealed that Indonesian students achieved an average mathematics score of 366, significantly below the OECD average (OECD, 2023). While PISA does not exclusively measure statistical understanding, these results underscore a systemic need for instructional approaches that foster reasoning and conceptual depth. True conceptual understanding requires students to identify underlying concepts, apply them in real-world contexts, and articulate relationships among mathematical ideas. In statistics, this is paramount because numerical data must be logically connected to real-world situations to form valid conclusions (Jannah & Hayati, 2024).

Alongside conceptual mastery, learning independence is a critical determinant of mathematical success. Learning independence encompasses a student's capacity to initiate tasks, manage the learning process, and self-evaluate outcomes—traits inextricably linked to self-regulated learning (Zimmerman, 2002). Because statistical analysis inherently requires active data exploration and autonomous decision-making, learning environments must afford students the autonomy to explore information and self-evaluate. Consequently, fostering learning independence is not merely a behavioral goal but a cognitive necessity for mastering statistics.

One instructional approach well-suited to facilitate this active exploration is discovery learning. Rooted in Bruner's (1966) cognitive theory, discovery learning empowers students to construct knowledge by actively identifying patterns, formulating relationships, and deducing conclusions. However, unguided discovery can be counterproductive, necessitating structured scaffolding (Mayer, 2004). While previous research affirms the positive impact of guided discovery on mathematical abilities (Khairunnisa & Juandi, 2022; Romadon & Mahmudi, 2019) and algebraic mastery (Marion et al., 2023), its specific application to junior high school statistics remains underexplored.

To maximize the efficacy of discovery learning, appropriate pedagogical scaffolding is essential. Contextual student worksheets provide this structure by offering a logical sequence of tasks that bridge abstract mathematical concepts with meaningful,

real-world situations. Previous research confirms that contextual learning enhances conceptual understanding (Brinus et al., 2019), and carefully designed contextual worksheets can foster learning independence (Farhana et al., 2022). Integrating these worksheets within a discovery learning framework creates a structured yet student-centered environment that supports both conceptual exploration and self-regulated learning (Balazinec et al., 2024; Lahdenperä et al., 2022).

Despite robust individual evidence supporting discovery learning, contextual materials, and self-regulated learning, significant gaps remain in the literature. First, existing studies predominantly investigate mathematical achievement in isolation, rarely addressing cognitive outcomes (conceptual understanding) and behavioral traits (learning independence) simultaneously. Second, research on discovery learning frequently focuses on mathematical domains outside of statistics or relies heavily on digital environments. Finally, the specific synergistic effect of integrating discovery learning with contextual student worksheets in secondary school statistics has received limited scholarly attention.

To address these gaps, the present study investigates the enhancement of statistical conceptual understanding and learning independence among junior high school students through Contextual Worksheet-Assisted Discovery Learning. By examining these dual outcomes simultaneously, this study provides a comprehensive perspective on the intervention's pedagogical efficacy. Specifically, this study aims to answer the following research questions: (1) to what extent does contextual worksheet-assisted discovery learning enhance students' statistical conceptual understanding?, (2) how does this instructional approach improve students' learning independence?

METHODS

This study employed a quantitative approach with a pre-experimental one-group pretest–posttest design involving one class and no comparison or control group. The design consisted of three stages: pretest (O_1), instructional implementation (X), and posttest (O_2). It was used as a classroom-based preliminary design to examine changes in students' statistical conceptual understanding and learning independence before and after the implementation of Discovery Learning assisted by contextual student worksheets. The research design can be illustrated as follows:

O₁ X O₂

Description:

O₁ : Pretest administered before the instructional implementation

X : Implementation of Discovery Learning assisted by contextual student worksheets

O₂ : Posttest administered after the instructional implementation

Because this design did not include a comparison or control group, it did not control for maturation, prior learning, testing effects, or other concurrent influences. Therefore, differences between the pretest and posttest were interpreted as pretest–posttest changes rather than definitive causal effects of the instructional approach.

The research was conducted at one Muhammadiyah Islamic junior high school in Garut Regency, West Java, during the second semester of the 2024/2025 academic year. The participants were 29 students from class IX B, selected through purposive sampling in consultation with the mathematics teacher.

The selection criteria were: (1) regular participation in mathematics learning activities; (2) suitability of the class characteristics for the planned Discovery Learning activities; and (3) ability to participate in and complete the pretest, instructional implementation, and posttest. The selection was made in consultation with the mathematics teacher, who was familiar with the students' learning conditions and classroom characteristics. Thus, the sample was selected based on the practical and instructional characteristics required for the study rather than through random sampling.

Data were collected through tests, questionnaires, and documentation. The test was administered before and after the instructional implementation to measure students' statistical conceptual understanding. The questionnaire was used to identify students' learning independence, while documentation was used to support the implementation and data collection processes.

The instruments consisted of a statistical conceptual understanding test and a learning independence questionnaire. The statistical conceptual understanding test consisted of multiple-choice and essay questions covering the statistical concepts taught during the instructional implementation. The items were developed based on five indicators of conceptual understanding: (1) restating concepts, (2) classifying objects based on concepts, (3) providing examples and non-examples, (4) representing concepts in different forms, and (5) applying concepts in problem solving.

The learning independence questionnaire consisted of 10 statements, each rated on a four-point Likert scale ranging from Strongly Agree to Strongly Disagree. The questionnaire included both positive and negative statements and was developed based on five indicators: (1) learning initiative, (2) utilization of learning resources, (3) learning persistence, (4) learning time management, and (5) self-evaluation.

The operational indicators and their descriptions are presented in Tables 1 and 2.

Table 1. Statistical Conceptual Understanding

No	Indicator	Description
1	Restating concepts	Students can explain the meaning of statistical concepts.
2	Classifying objects based on concepts	Students can identify and distinguish statistical data based on the characteristics of the concepts.
3	Providing examples and non-examples	Students can identify examples of statistical concepts and data presentation methods.
4	Representing concepts in different forms	Students can represent and interpret statistical data in tables and diagrams.
5	Applying concepts	Students can apply statistical concepts to calculate and determine statistical measures.

Table 2. Learning Independence

No	Indicator	Description
1	Learning Initiative	Students attempt to understand the material and find solutions independently.
2	Utilization of Learning Resources	Students seek additional learning resources.
3	Learning Persistence	Students do not give up easily and do not depend on others.
4	Learning Time Management	Students manage their study time and complete assignments.
5	Self-Evaluation	Students assess and improve their learning outcomes.

Before data collection, the research instruments were reviewed by experts to assess their alignment with the research objectives, indicators, and content, and their suitability for the target students. The validation involved three validators: two university lecturers in mathematics education and one mathematics teacher. The validators reviewed the

statistical conceptual understanding test and the learning independence questionnaire based on the indicators specified in the research instruments.

The validation process was limited to expert judgment. No statistical item validity or internal-consistency reliability analyses were conducted in this study. Therefore, the study does not report item validity coefficients, Cronbach's alpha, or other statistical reliability coefficients. The absence of statistical validity and reliability testing is acknowledged as a methodological limitation and should be considered when interpreting the findings.

The collected data were quantitatively analyzed using pretest and posttest scores. Descriptive statistics were used to summarize the data, including the minimum, maximum, mean, and standard deviation.

For both outcome variables, normality was assessed using the Shapiro–Wilk test because the sample comprised fewer than 50 students (Ghasemi & Zahediasl, 2012). The normality results were considered when determining the appropriate paired-comparison procedure. A paired-sample t-test was used for the statistical conceptual understanding data, as both the pretest and posttest distributions met the normality criterion. The Wilcoxon Signed-Rank Test was used for learning independence because the pretest distribution did not meet the normality criterion.

N-Gain analysis was additionally used to describe the level of improvement in students' statistical conceptual understanding based on the pretest and posttest scores, using Hake's (1999) classification. The inferential tests and N-Gain analysis were interpreted as evidence describing pretest–posttest changes. Because the study used a single group without a comparison group, these analyses were not interpreted as causal evidence of the effectiveness of the instructional approach.

RESULTS AND DISCUSSION

1. Students' Statistical Conceptual Understanding

1.1 Descriptive Statistics of Students' Statistical Conceptual Understanding

Data on students' statistical conceptual understanding were obtained through pretest and posttest assessments administered before and after the implementation of discovery learning assisted by contextual student worksheets. The descriptive statistics are presented in Table 3.

Table 3. Descriptive Statistics of Statistical Conceptual Understanding

Statistics	Pretest	Posttest
Number of Students	29	29
Minimum Score	24	32
Maximum Score	96	100
Mean	64.97	76.14
Standard Deviation	15.37	19.20

As shown in Table 3, the mean score increased from 64.97 on the pretest to 76.14 on the posttest. The minimum score improved from 24 to 32, and the maximum score increased from 96 to 100. These results indicate a positive pretest–posttest change in students' statistical conceptual understanding following the implementation of the instruction.

1.2 Normality Test

The Shapiro–Wilk test was conducted to assess the normality of the pretest and posttest scores prior to hypothesis testing, given the small sample size ($N < 50$).

Table 4. Normality Test of Statistical Conceptual Understanding

Tests of Normality			
		Shapiro-Wilk	
	Statistic	Df	Sig.
Pretest	.964	29	.400
Posttest	.938	29	.091

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

The Shapiro–Wilk results showed that neither the pretest score distribution ($W = .964$, $p = .400$) nor the posttest score distribution ($W = .938$, $p = .091$) significantly deviated from normality at the .05 alpha level. Consequently, a paired-samples t -test was deemed appropriate.

1.3 Paired Sample t -test

A paired-sample t -test was conducted to examine whether there was a statistically significant difference in students' statistical conceptual understanding between the pretest and posttest. The results are presented in Table 5.

Table 5. Results of the Paired Sample t-test

		Pair 1	
Paired Differences	Mean	Pretest – Posttest	
		-11.172	
	Std. Deviation	11.483	
	Std. Error Mean	2.132	
	95% Confidence Interval of the Difference	Lower	-15.540
		Upper	-6.804
T	-5.239		
Df	28		
Sig. (2-tailed)	.000		

The analysis revealed a statistically significant difference between the pretest and posttest scores, $t(28) = -5.24$, $p < .001$. The mean difference was -11.17 (calculated as pretest minus posttest). The corresponding standardized within-group effect size was approximately $d = 0.97$, indicating a large magnitude of change. While this effect size indicates substantial pretest-posttest improvement, it should be interpreted descriptively rather than as definitive evidence of a causal treatment effect given the single-group design.

1.4 Improvement of Conceptual Understanding Based on N-Gain

The level of improvement in students' statistical conceptual understanding was further examined using the N-Gain score. The average N-Gain was 0.41, which was categorized as moderate according to Hake's (1999) classification.

The distribution of N-Gain categories is presented in Figure 1.

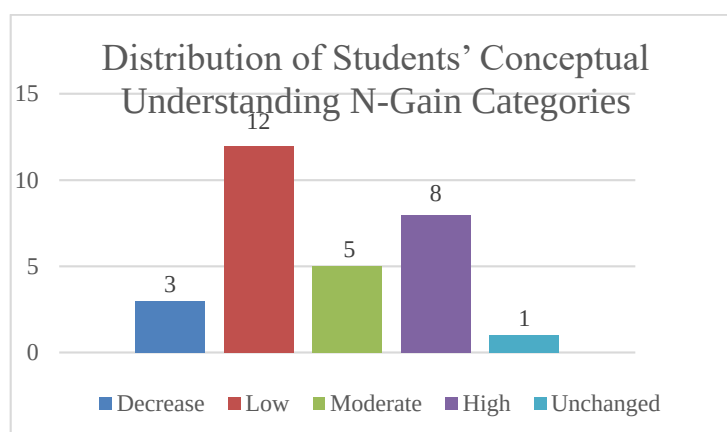


Figure 1. Distribution of N-Gain Categories of Students' Statistical Conceptual Understanding

The N-Gain distribution showed variation in students' individual improvement. Three students experienced a decrease in scores; 12 students were classified in the low-

gain category, 5 in the moderate-gain category, 8 in the high-gain category, and 1 showed no change. These results indicate that the magnitude of pretest-posttest change was not uniform across students.

2. Students' Learning Independence

2.1 Descriptive Statistics of Learning Independence

Data on students' learning independence were collected using a questionnaire comprising 10 statements with four response options. The questionnaire was administered before and after the implementation of Discovery Learning assisted by contextual student worksheets. The descriptive results are presented in Table 6.

Table 6. Descriptive Statistics of Learning Independence

Data	Mean	Maximum Score	Minimum Score
Pretest	28.34	40	13
Posttest	30.41	40	18

As shown in Table 6, the mean score of learning independence increased from 28.34 on the pretest to 30.41 on the posttest. The minimum score also increased from 13 to 18, while the maximum score remained 40. These descriptive results show a positive pretest–posttest change in students' learning independence.

2.2 Normality Test

The Shapiro-Wilk test was conducted to examine the normality of the learning independence scores before selecting the appropriate hypothesis test. The results are presented in Table 7.

Table 7. Normality Test of Students' Learning Independence

Tests of Normality			
Shapiro-Wilk			
	Statistic	Df	Sig.
Pretest	.899	29	.009
Posttest	.957	29	.285
a. Lilliefors Significance Correction			

The pretest significance value (.009) was lower than .05, indicating that the pretest scores did not meet the normality assumption. In contrast, the posttest significance value (.285) was greater than .05. Because the normality assumption was not satisfied for the pretest data, the Wilcoxon Signed Rank Test was used to examine the pretest–posttest difference.

2.3 Wilcoxon Signed Rank Test

The Wilcoxon Signed-Rank Test was conducted to examine differences in students' learning independence between the pretest and posttest. The results are presented in Table 8.

Table 8. Results of the Wilcoxon Signed Rank Test

Test Statistics ^a	
Z	Posttest – Pretest -3.167 ^b
Asymp. Sig. (2-tailed)	.002
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

The Wilcoxon Signed Rank Test indicated a statistically significant pretest–posttest difference, $Z = -3.167$, $p = .002$. The standardized effect-size estimate, calculated as $r = |Z|/\sqrt{N}$, was approximately 0.59, indicating a moderate-to-large magnitude of within-group change. This estimate describes the magnitude of the observed pretest–posttest difference and does not establish that the instructional intervention alone caused the change.

2.4 Categories of Students' Learning Independence

Students' learning independence was also categorized to examine changes in the distribution of scores between the pretest and posttest. The results are presented in Figure 2.

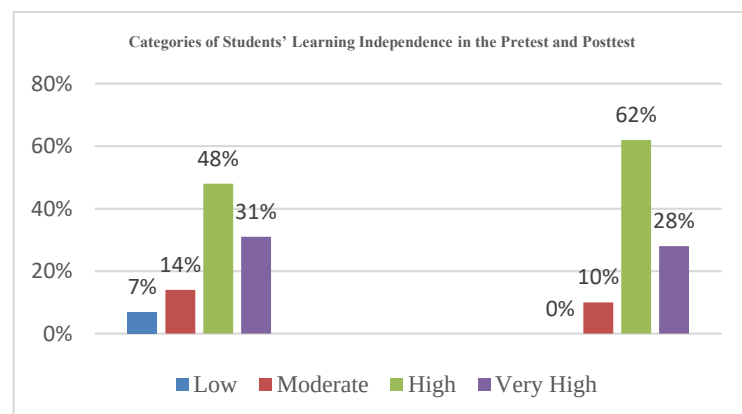


Figure 2. Categories of Students' Learning Independence in the Pretest and Posttest

Figure 2 shows a shift in the distribution of students' learning independence across categories. In the pretest, 7% of students were categorized as having low learning independence, 14% as moderate, 48% as high, and 31% as very high. In the posttest, the

proportion of students in the low category decreased to 0%, while the proportion in the moderate category decreased from 14% to 10%. Meanwhile, the proportion of students in the high category increased from 48% to 62%, whereas the very-high category decreased slightly from 31% to 28%.

Overall, the distribution indicates that the proportion of students in the low and moderate categories decreased, while the proportion in the high category increased. These descriptive changes are consistent with the significant pretest–posttest difference identified by the Wilcoxon Signed-Rank Test. However, the category distribution describes changes in students' scores and should not be interpreted as evidence of a causal effect of the instructional approach.

The results showed statistically significant pretest–posttest changes in students' statistical conceptual understanding and learning independence following the implementation of Discovery Learning assisted by contextual student worksheets. Statistical conceptual understanding increased from a mean of 64.97 to 76.14, with an average N-Gain of 0.41 (moderate), while learning independence increased from 28.34 to 30.41. Because the study used a one-group pretest–posttest design without a comparison group, these findings indicate observed changes rather than definitive causal effects.

The change in statistical conceptual understanding can be related to the characteristics of Discovery Learning, which encourages students to identify information, analyze data, discuss ideas, and formulate conclusions. These activities provide opportunities to construct and connect statistical concepts through active learning experiences, consistent with Bruner's (1966) theory of discovery learning. The finding also agrees with Nadia et al. (2024), who reported positive changes in students' mathematical conceptual understanding following Discovery Learning. The contextual worksheets further structured these activities by presenting statistical concepts through situations related to students' experiences. This contextualization may have helped students connect concrete situations with formal statistical concepts, consistent with Wijayanti and Subekti (2026) and Ipat and Nindiasari (2024).

Learning independence also showed a significant pretest–posttest change, with a Wilcoxon statistic $Z = -3.167$, $p = .002$, and an effect size $r \approx 0.59$. The student-centered design provided opportunities for students to seek information, participate in discussions,

complete tasks, and formulate conclusions with less dependence on direct teacher explanation. These experiences may support initiative, persistence, resource use, time management, and self-evaluation, consistent with Zimmerman's (2002) self-regulated learning perspective. Umamiyah et al. (2022) similarly emphasized the relationship between active learning involvement and learning independence. Hariyani et al. (2024) also examined Discovery Learning in relation to students' self-regulated learning, providing further support for the importance of learner regulation in discovery-oriented mathematics learning. In addition, Putri and Mahmudi (2025) reported changes in mathematical conceptual understanding and self-regulated learning through a Discovery Learning approach, although their study involved differentiated instruction in high school trigonometry. The contextual worksheets may also have provided structured guidance that gradually encouraged students to assume greater responsibility for learning tasks.

Although conceptual understanding increased significantly, the moderate N-Gain (0.41) and variation in individual gains indicate that students did not benefit uniformly. Three students experienced a decrease; 12 showed low gain; five showed moderate gain; eight showed high gain; and one showed no change. Differences in prior knowledge, readiness, engagement, and familiarity with discovery-oriented learning may have contributed to this variation. Students with weaker prerequisite knowledge or less experience with independent exploration may require more explicit guidance and scaffolding. Previous research on guided discovery has reported improvements in students' mathematical conceptual understanding, suggesting that structured guidance can support students in constructing mathematical concepts (Mawaddah & Maryanti, 2016). This need for structured guidance is also consistent with Vygotsky's (1978) view that learning can be supported through interaction and scaffolding within students' developing capabilities. In addition, the duration of the instructional implementation may have limited students' opportunities to explore, discuss, verify, and reflect on statistical concepts. Longer implementation and differentiated scaffolding may therefore be considered in future studies.

The non-normal distribution of the learning independence pretest also indicates variation in students' initial conditions. Pretest scores ranged from 13 to 40, suggesting differences in learning initiative, persistence, time management, resource use, and self-evaluation. Because the normality criterion was not met for the pretest distribution, the

Wilcoxon Signed-Rank Test was used for the paired comparison. The increase in learning independence should nevertheless be interpreted with caution, as such behavioral and self-regulatory characteristics may develop gradually and be influenced by prior learning experiences, maturation, testing effects, and other classroom activities.

From a practical perspective, contextual worksheets can be used to organize discovery-oriented statistics learning, but students may still require appropriate guidance. Guiding questions, graduated tasks, examples, feedback, and reflection activities can provide scaffolding for students with weaker prerequisite knowledge or lower initial independence in learning. Thus, the combination of active exploration and structured contextual materials may support the simultaneous development of conceptual understanding and independent learning behaviors.

This study has several limitations. The one-group pretest–posttest design and a small sample of 29 students from one class limit causal interpretation and transferability. In addition, the instruments were evaluated using expert judgment by three validators, without statistical analyses of item validity and internal consistency reliability. Future research should therefore use comparison groups, larger and more diverse samples, longer instructional periods, and stronger psychometric evidence. Further studies may also examine whether prior knowledge and initial independence in learning influence the magnitude of changes during discovery-oriented statistics learning.

CONCLUSION

This study provides empirical evidence that implementing discovery learning, supported by contextual student worksheets, yields statistically significant improvements in junior high school students' statistical conceptual understanding and learning independence. The integration of structured, real-world contexts within a discovery-oriented framework affords students the autonomy to actively explore statistical concepts, thereby fostering both cognitive mastery and self-regulated learning behaviors. Consequently, contextual worksheets emerge as a highly viable pedagogical tool for facilitating student-centered statistics instruction.

While the findings are promising, several methodological limitations must be acknowledged. First, the reliance on a pre-experimental, one-group pretest–posttest design with a small sample size ($N = 29$) precludes the establishment of definitive causal

relationships and limits the generalizability of the results. Maturation, testing effects, or concurrent classroom dynamics cannot be fully ruled out as confounding variables. Second, the research instruments were validated exclusively through expert judgment; rigorous statistical analyses of item validity and internal consistency reliability were not conducted. To build upon these findings, future research should employ quasi-experimental or randomized controlled trial (RCT) designs incorporating appropriate comparison groups to establish causality. Studies should engage larger, more demographically diverse samples over extended instructional periods to assess long-term retention of conceptual understanding and independent learning behaviors. Furthermore, future investigations must subject their measurement instruments to comprehensive psychometric testing. Exploring how baseline prior knowledge and initial self-regulation levels moderate the efficacy of discovery learning would also provide valuable insights for differentiated instruction.

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Author Contribution	: AS: Conceptualization, Data Collection, Data Processing, Formal Analysis, Methodology, Writing-Original Draft, and Editing; NN: Writing-Review & Editing, Validation, and Supervision; TSS: Validation, Supervision, and Writing-Review & Editing.
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REFERENCES

- Balazinec, M., Radanović, I., & Bulić, M. (2024). Self-regulated learning in science classes with a discovery learning environment and collaborative discovery learning environment. *Education Sciences*, 14(6), 669. <https://doi.org/10.3390/educsci14060669>
- Brinus, K. S. W., Makur, A. P., & Nendi, F. (2019). Pengaruh model pembelajaran kontekstual terhadap pemahaman konsep matematika siswa SMP. *Mosharafa: Jurnal Pendidikan Matematika*, 8(2), 261–272. <https://doi.org/10.31980/mosharafa.v8i2.558>
- Bruner, J. S. (1966). *Toward a theory of instruction*. Harvard University Press.
- Farhana, N. S., Zawawi, I., & Suryanti, S. (2022). Pengembangan LKPD berbasis masalah kontekstual untuk meningkatkan kemandirian peserta didik. *AKSIOMA: Jurnal Matematika dan Pendidikan Matematika*, 13(3), 527–536. <https://doi.org/10.26877/aks.v13i3.13637>
- Gal, I. (2002). Adults' statistical literacy: Meanings, components, responsibilities. *International Statistical Review*, 70(1), 1–25. <https://doi.org/10.1111/j.1751-5823.2002.tb00336.x>
- Ghasemi, A., & Zahediasl, S. (2012). Normality tests for statistical analysis: A guide for non-statisticians. *International Journal of Endocrinology and Metabolism*, 10(2), 486–489. <https://doi.org/10.5812/ijem.3505>
- Hake, R. R. (1999). *Analyzing change/gain scores*. Unpublished manuscript, Indiana University.
- Hariyani, L., Yurniwati, Y., & Utami, A. D. (2024). The effect of discovery learning in mathematics learning on computational thinking in terms of self-regulated learning (SRL) in student. *Jurnal Elementaria Edukasia*, 7(2), 2801–2814. <https://doi.org/10.31949/jee.v7i2.9551>
- Ipat, I., & Nindiasari, H. (2024). Pengaruh pembelajaran kontekstual terhadap kemampuan pemahaman konsep matematika pada siswa SMA kelas XI. *Jurnal Lebesgue: Jurnal Ilmiah Pendidikan Matematika, Matematika dan Statistika*, 5(3), 2079–2087. <https://doi.org/10.46306/lb.v5i3.826>
- Jannah, M., & Hayati, M. (2024). Pentingnya kemampuan literasi matematika dalam pembelajaran matematika. *Griya Journal of Mathematics Education and Application*, 4(1), 40–54. <https://doi.org/10.29303/griya.v4i1.416>
- Kemendikbudristek. (2022). *Capaian pembelajaran mata pelajaran matematika fase D pada Kurikulum Merdeka*. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.
- Khairunnisa, K., & Juandi, D. (2022). Meta-analysis: The effect of discovery learning models on students' mathematical ability. *Jurnal Riset Pendidikan Matematika*, 9(2), 201–211. <https://doi.org/10.21831/jrpm.v9i2.49147>

- Lahdenperä, J., Rämö, J., & Postareff, L. (2022). Student-centered learning environments supporting undergraduate mathematics students to apply regulated learning: A mixed-methods approach. *Journal of Mathematical Behavior*, 66, 100949. <https://doi.org/10.1016/j.jmathb.2022.100949>
- Marion, Z., Abdullah, A. H., & Rahman, S. N. S. A. (2023). The effectiveness of the GeoGebra-assisted inquiry-discovery learning strategy on students' mastery and interest in algebraic expressions. *International Journal of Information and Education Technology*, 13(11), 1681–1695. <https://doi.org/10.18178/ijiet.2023.13.11.1977>
- Mawaddah, S., & Maryanti, R. (2016). Kemampuan pemahaman konsep matematis siswa SMP dalam pembelajaran menggunakan model penemuan terbimbing (discovery learning). *EDU-MAT: Jurnal Pendidikan Matematika*, 4(1), 76–85. <https://doi.org/10.20527/edumat.v4i1.2292>
- Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? *American Psychologist*, 59(1), 14–19. <https://doi.org/10.1037/0003-066X.59.1.14>
- Nadia, N., Yensy, N. A., Utari, T., Maulidiya, D., & Stiadi, E. (2024). Pengaruh model pembelajaran discovery learning terhadap kemampuan pemahaman konsep matematis SMP Negeri 2 Kota Bengkulu. *Jurnal Penelitian Pembelajaran Matematika Sekolah (JP2MS)*, 8(3), 429–439. <https://doi.org/10.33369/jp2ms.8.3.429-439>
- OECD. (2023). PISA 2022 results (Volume I). OECD Publishing. <https://doi.org/10.1787/53f23881-en>
- Putri, Z., & Mahmudi, A. (2025). The effect of discovery learning model based on differentiated instruction on high school students' mathematical conceptual understanding and self-regulated learning in trigonometric ratios material. *International Journal of Multicultural and Multireligious Understanding*, 12(9), 136–144. <https://doi.org/10.18415/ijmmu.v12i9.7011>
- Romadon, S., & Mahmudi, A. (2019). Penerapan pendekatan penemuan terbimbing untuk meningkatkan kemampuan pemahaman konsep matematis siswa. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 8(1), 58–64. <https://doi.org/10.24127/ajpm.v8i1.1684>
- Umamiyah, N., Fauziyah, N., & Khikmiyah, F. (2022). Pengaruh kemandirian belajar dan keterlibatan peserta didik terhadap hasil belajar matematika. *Didaktika: Jurnal Pemikiran Pendidikan*, 28(1), 1–14. <https://doi.org/10.30587/didaktika.v28i1.3612>
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Watson, J. M., & Callingham, R. (2003). Statistical literacy: A complex hierarchical construct. *Statistics Education Research Journal*, 2(2), 3–46. <https://doi.org/10.52041/serj.v2i2.553>
- Wijayanti, W., & Subekti, F. E. (2026). Development and experimental validation of discovery learning-based worksheets integrating cultural context to enhance students' mathematical literacy and self-regulated learning. *Journal of Advanced*

Sciences and Mathematics Education, 6(2), 113–133.
<https://doi.org/10.58524/jasme.v6i2.1178>

Zimmerman, B. J. (2002). *Becoming a self-regulated learner: An overview. Theory Into Practice*, 41(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2

