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INTEGRATING DEEP LEARNING APPROACHES INTO MATHEMATICS INSTRUCTION TO IMPROVE FORMULA MASTERY IN GRADE 5

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ABSTRACT

This study was motivated by the low level of mathematical formula mastery among fifth-grade elementary school students due to surface learning*, causing students to memorize formulas without understanding the concepts. This study aimed to analyze the effect of the* Deep Learning *approach through the* Discovery Learning *model on students' mastery of mathematical formulas compared with the* Cooperative Learning *model. This study employed a quasi-experimental method using a* non-equivalent control group design*. The sample consisted of 38 fifth-grade students at SDN Kandangan 02 and SDN Kandangan 03. Data were collected using a hybrid test and analyzed through normality, homogeneity, and* Independent Samples T-Test *using IBM SPSS. The results showed that the experimental group I achieved a higher posttest mean score (73.684) than the experimental group II (58.947). The t-test result indicated a significant difference between the two groups with t = 2.657 and significance value 0.012 < 0.05. Therefore, the* Deep Learning *approach through the* Discovery Learning *model was more effective in improving students' mastery of mathematical formulas.*

Keywords*: Cooperative Learning; Deep Learning; Discovery Learning*; mathematical formula mastery

ABSTRAK

Penelitian ini dilatar belakangi oleh rendahnya penguasaan rumus matematika siswa kelas V sekolah dasar akibat pembelajaran yang masih bersifat *surface learning*, sehingga siswa cenderung menghafal rumus tanpa memahami konsepnya. Penelitian ini bertujuan untuk menganalisis pengaruh pendekatan *Deep Learning* melalui model *Discovery Learning* terhadap penguasaan rumus matematika siswa dibandingkan dengan model *Cooperative Learning*. Penelitian ini menggunakan metode kuasi eksperimen dengan desain *non-equivalent control group design*. Sampel penelitian berjumlah 38 siswa kelas V di SDN Kandangan 02 dan SDN Kandangan 03. Data dikumpulkan menggunakan *hybrid test* dan dianalisis melalui uji normalitas, homogenitas, dan *Independent Samples T-Test* menggunakan IBM SPSS. Hasil penelitian menunjukkan bahwa nilai rata-rata *posttest* kelas eksperimen I sebesar 73,684 lebih tinggi dibandingkan kelas eksperimen II sebesar 58,947. Hasil uji t menunjukkan terdapat perbedaan yang signifikan antara kedua kelompok dengan nilai t = 2,657 dan signifikansi 0,012 <

0,05. Dengan demikian, pendekatan *Deep Learning* melalui model *Discovery Learning* lebih efektif dalam meningkatkan penguasaan rumus matematika siswa kelas V sekolah dasar.

Kata Kunci: *Cooperative Learning, Deep Learning*; *Discovery Learning*;; penguasaan rumus matematika

A. Introduction

Mathematics is a fundamental scientific discipline that focuses on the study of numbers, patterns, structures, and relationships, which play an essential role in developing students' logical, analytical, and systematic thinking skills (Yabashiru et al., 2025). In the context of learning, mathematics is not merely about performing calculations but involves the process of constructing meaning through symbolic representations and mathematical discourse (Herheim, 2023). Therefore, mastery of mathematical formulas becomes a crucial component, as formulas function as cognitive tools that help students understand relationships between mathematical concepts (Arfizeah et al., 2025).

Ideally, mathematics learning in elementary school should emphasize conceptual understanding rather than rote memorization, enabling students to explain concepts, apply them in problem-solving situations, and connect various mathematical ideas (Maharani et al., 2025). This expectation aligns with the concept of relational understanding, where students are required to comprehend the structure and logic underlying formulas rather than merely applying procedures mechanically (Herheim, 2023). However, in practice, many students still experience difficulties in mastering mathematical formulas due to the dominance of surface learning approaches that prioritize memorization without deep conceptual understanding (Maharani et al., 2025).

As part of the preliminary study, a survey was conducted using a Y-chart to explore students' perceptions and experiences during the learning process. The Y-chart is a reflective instrument that allows students to express what they see, hear, and feel throughout classroom activities, thereby providing insights into their understanding and learning experiences. In this study, the Y-chart was used to capture students' perceptions of mathematical formulas, particularly in revealing their tendency to perceive formulas as abstract and difficult concepts (Relmasira & Thrupp, 2016; Sabuna et al., 2025).

Empirical evidence further strengthens this issue, as findings from a code map visualization reveal that students' understanding of mathematical formulas is predominantly characterized by surface learning patterns, particularly memorization without meaningful comprehension (Maharani et al., 2025). The visualization demonstrates that the main problem cluster is centered on students' perception of formulas as mere calculation tools, which is strongly associated with feelings of difficulty and complexity in learning mathematics (Maharani et al., 2025). Furthermore, the frequency of deep conceptual understanding is significantly lower compared to instrumental understanding, indicating that most students have not yet achieved meaningful learning outcomes (Maharani et al., 2025). This condition reflects the dominance of instrumental understanding, where students tend to follow procedures without understanding the underlying reasoning behind mathematical formulas (Samosir et al., 2023).

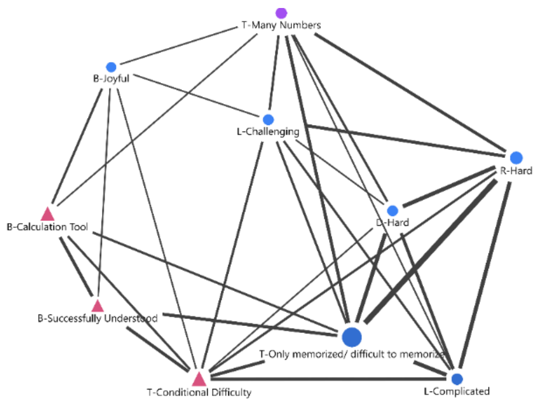

Figure 1 Code Map Visualization of Cognitive Challenges (Blue Circles) and Success Factors (Pink Triangles) in Formula Mastery

As a consequence, students experience difficulties in connecting mathematical concepts and applying formulas in various contexts, which ultimately hinders the development of higher-order thinking skills (Diputra et al., 2025). To address this issue, it is necessary to implement innovative learning approaches that promote meaningful and in-depth understanding, one of which is the Deep Learning approach (Nafi'ah & Faruq, 2025). Deep Learning emphasizes students' active involvement in constructing knowledge, connecting new information with prior knowledge, and developing understanding through mindful, meaningful, and joyful learning experiences (Iriawan et al., 2025). This approach is considered effective in transforming surface learning into deep conceptual understanding in mathematics education (Mutmainnah et al., 2025).

One learning model that is closely aligned with the principles of Deep Learning is Discovery Learning, which encourages students to actively explore, investigate, and construct their own knowledge through direct learning experiences (Mansyur et al., 2024). Through this model, students are guided to identify problems, collect and process data, verify findings, and formulate conclusions, thereby fostering deeper cognitive engagement and long-term understanding (Khoiriyah & Fatonah, 2024). Discovery Learning is a student-centered approach that emphasizes students' active involvement in constructing knowledge through exploration, investigation, experimentation, and problem-solving activities. In this process, students are encouraged to discover concepts independently through meaningful learning experiences, while teachers act as facilitators who guide and support the learning process (Milenković et al., 2025).

Furthermore, this approach promotes students' motivation, creativity, critical thinking, and deeper conceptual understanding, as learners actively participate in the learning process rather than passively receiving information (Aldalur & Perez, 2023). It also enables students to connect prior knowledge with new experiences through exploratory and discussion-based activities, resulting in more meaningful and long-lasting learning outcomes, particularly in mathematics learning (Andrews & Sunde, 2026).

From a theoretical perspective, Discovery Learning is grounded in constructivist learning theory, influenced by the ideas of Piaget, Vygotsky, and Dewey, and systematically developed by Bruner, who emphasized that learning becomes more meaningful when students actively construct knowledge through their own cognitive processes. Therefore, Discovery Learning is considered highly relevant for supporting deep conceptual understanding in mathematics learning.

On the other hand, the Cooperative Learning model emphasizes collaboration among students in small groups to achieve shared learning goals and enhance understanding through social interaction (Yustiara et al., 2023). Through this approach, students are encouraged to engage in discussion, share knowledge, and support one another in the learning process.

However, although this model effectively facilitates peer interaction, it tends to place greater emphasis on group processes rather than individual cognitive exploration and deep conceptual understanding (Rahmatika & Olii, 2025). Therefore, comparing Discovery Learning integrated with the Deep Learning approach and Cooperative Learning becomes important to determine their relative effectiveness in improving students' mastery of mathematical formulas (Syahri, 2023). Despite the growing interest in the implementation of Deep Learning in education, most previous studies have focused on general learning outcomes rather than specifically examining students' mastery of mathematical formulas (Mutmainnah et al., 2025). This indicates a research gap that needs to be addressed, particularly in the context of elementary school mathematics learning (Maharani et al., 2025).

Based on these considerations, this study aims to analyze the effect of integrating the Deep Learning approach through the Discovery Learning model on improving fifth-grade students' mastery of mathematical formulas compared to the Cooperative Learning model (Syahri, 2023). This research is expected to contribute to the development of effective learning strategies that promote deep conceptual understanding and reduce surface learning in elementary mathematics education (Fauzan et al., 2024).

B. Methods

This study employed a quasi-experimental design with a non-equivalent control group structure to examine the effect of the applied learning models. The structure of the research design can be illustrated in Table 1.

Tabel 1. The One Group Pretest and Posttest Design can be illustrated in Table 1 as follows

Group	Pre-Test	Treatment	Post-Test
Group 1	O1	X1	O2
Group 2	O1	X2	O2

Syahri (2023)

Table 1 illustrates the arrangement of the experimental and control groups, including the sequence of pre-test, treatment, and post-test administered in both groups. In this design, Group 1 (Experimental Group I) was treated using the Discovery Learning model integrated with a Deep Learning approach, while Group 2 (Experimental Group II) received instruction through the Cooperative Learning model.

The notation used in Table 1 is described as follows: O_1 refers to the pre-test administered before the treatment, X_1 denotes the treatment using the Discovery Learning model integrated with the Deep Learning approach, X_2 represents the treatment using the Cooperative Learning model, and O_2 refers to the post-test administered after the treatment.

The research procedure consisted of three main stages: pretest, treatment, and posttest. The pretest was administered to measure students' initial abilities, followed by the implementation of the respective learning models in each group, and concluded with a posttest to assess students' improvement in mastering mathematical formulas.

To provide a clearer visualization of the research procedure, a conceptual framework is presented in Figure 1

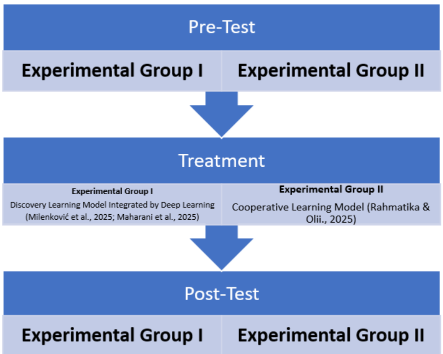

Figure 1 Conceptual Framework of the Research Design

Data were collected using a hybrid test instrument designed to measure students' cognitive understanding in constructing, explaining, and applying mathematical formulas related to cube and rectangular prism volume. The instrument was developed based on established principles of research measurement to ensure its validity and reliability in capturing students' conceptual understanding (Arfizeah et al., 2025).

In addition to quantitative data, this study also employed a qualitative instrument in the form of a Y-Chart to explore students' perceptions and learning experiences in more depth. The Y-Chart is a reflective graphic organizer that allows students to express what they see, hear, and feel during the learning process (Relmasira & Thrupp, 2016; Sabuna et al., 2025)

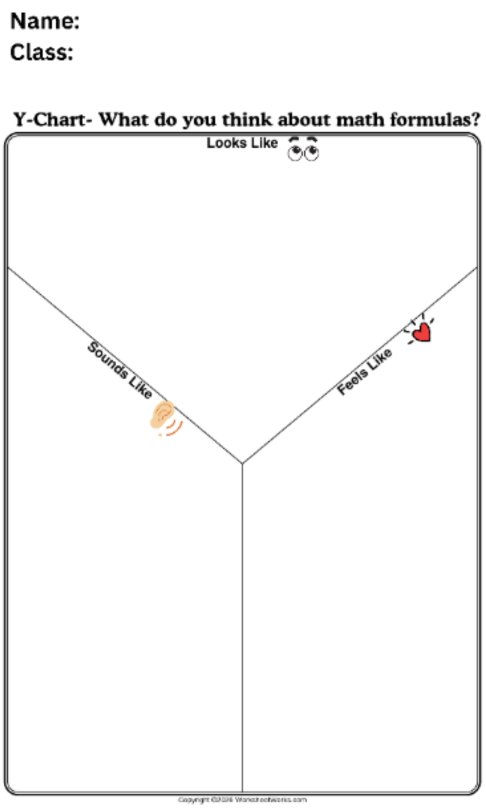

Figure 2 Y-Chart Template

Through this framework, students' perceptions of mathematical formulas were analyzed from visual (*looks like*), auditory (*sounds like*), and emotional (*feels like*) dimensions. This instrument provides a more comprehensive understanding of students' learning experiences and complements the quantitative findings.

Data analysis was conducted using both descriptive and inferential statistics to compare the performance of the experimental and control groups. Prior to hypothesis testing, prerequisite tests were performed, including the normality test using the Shapiro–Wilk method and the homogeneity test using Levene's Test with the assistance of IBM SPSS software (Nisa, 2025; Azizah et al., 2025). To test the hypothesis, an Independent Samples t-test was applied to determine whether there was a statistically significant difference between the mean scores of the two groups (Chicco et al., 2025). A significance value of less than 0.05 was used as the criterion for rejecting the null hypothesis, indicating a significant effect of the treatment.

C. Results and Discussion

The results of this study present the comparison of students' mastery of mathematical formulas between the experimental group and the control group based on pretest and posttest scores. The descriptive statistics of the pretest scores are presented in Table 2.

Table 2. Pretest Scores

No	Class Pretest Experiment (Discovery Learning)	Class Pretest Control (Cooperative Learning)
1.	42.5	57.5
2.	60	30
3.	62.5	55
4.	35	42.5
5.	77.5	65
6.	57.5	50
7.	42.5	55
8.	45	45
9.	30	45
10.	80	32.5
11.	52.5	62.5
12.	47.5	47.5
13.	32.5	55
14.	60	50
15.	52.5	52.5
16.	42.5	47.5
17.	82.5	67.5
18.	50	52.5
19.	30	47.5

The detailed distribution of pretest scores for both groups is shown in Table 3, which indicates that the initial abilities of students in the experimental and control groups were relatively similar.

Table 3. Pretest Data

		Pre ExperimentClass_Discovery	Pre ControlClass_Cooperative
N	Valid	19	19
	Missing	0	0
Mean		51.7105	50.5263
Std. Deviation		16.00895	9.59524
Minimum		30.00	30.00
Maximum		82.50	67.50

To ensure the validity of further statistical analysis, a normality test using the Shapiro–Wilk method was conducted, and the results are presented in Table 4. The findings show that the significance values for both groups were greater than 0.05, indicating that the pretest data were normally distributed.

Table 4. Tests of Normality (Pretest normality using Shapiro Wilk)

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre Experiment Class_Discovery	.112	19	.200*	.935	19	.217
Pre ControlClass_Cooperative	.124	19	.200*	.961	19	.592

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

A homogeneity test using Levene's Test was also performed, and the results are shown in Table 5, indicating that the data were homogeneous as the significance value exceeded 0.05.

Table 5. Pre-test Homogeneity

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.[a]
PreTest Score	Based on Mean	3.720	1	36	.062
	Based on Median	3.705	1	36	.062
	Based on Median and with adjusted df	3.705	1	34.130	.063
	Based on trimmed mean	3.777	1	36	.060

Furthermore, an Independent Samples t-test was conducted to examine differences between the two groups prior to treatment, as presented in Table 6. The results indicate that there was no statistically significant difference between the pretest scores of the experimental and control groups, confirming that both groups had equivalent initial abilities.

Table 6. Independent Samples Test Pretest

Independent Samples Test					
		t-test for Equality of Means			
				Significance	
		t	df	One-Sided p	Two-Sided p
Pre Test Score	Equal variances assumed	.277	36	.392	.784
	Equal variances not assumed	.277	29.454	.392	.784

h After the implementation of the learning treatments, the descriptive statistics of posttest scores are presented in Table 7. The results show that the experimental group achieved higher mean scores compared to the control group, indicating an improvement in students' mastery of mathematical formulas after the intervention.

Table 7. Posttest Score

No	Class Posttest Experiment (Discovery Learning)	Class Posttest Control (Cooperative Learning)
1.	62.5	72.5
2.	87.5	25
3.	90	35
4.	62.5	45
5.	97.5	45
6.	72.5	60
7.	90	60
8.	90	57.5
9.	35	65
10.	90	25
11.	55	65

12.	65	52.5
13.	77.5	65
14.	70	55
15.	70	67.5
16.	85	80
17.	80	92.5
18.	65	72.5
19.	55	80

The detailed distribution of posttest data is further presented in Table 8, which provides a clearer comparison of score variations between the experimental and control groups.

Table 8. Post Test Data

		Discovery	Cooperative
N	Valid	19	19
	Missing	19	19
Mean		73.684	58.947
Std. Deviation		16.0375	18.0915
Minimum		35.0	25.0
Maximum		97.5	92.5

To validate the assumptions for hypothesis testing, a normality test was conducted on the posttest data using the Shapiro–Wilk method, as presented in Table 9. The results show that the data were normally distributed, as the significance values were greater than 0.05.

Table 9. Tests of Normality (Posttest normality using Shapiro Wilk)

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Discovery	.128	19	.200*	.943	19	.293
Cooperative	.105	19	.200*	.964	19	.659

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

A homogeneity test was also performed on the posttest data, and the results are shown in Table 10, indicating that the variance between the groups was homogeneous.

Table 10. Post-test Homogeneity

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.[a]
PostTest Score	Based on Mean	.055	1	36	.816
	Based on Median	.039	1	36	.844
	Based on Median and with adjusted df	.039	1	33.984	.844
	Based on trimmed mean	.048	1	36	.827

An Independent Samples t-test was then conducted to determine the significance of differences between the two groups after the treatment, as presented in Table 11. The results reveal a statistically significant difference, as the significance value was less than 0.05, indicating that the Deep Learning approach implemented through the Discovery Learning model had a significant effect on students' mastery of mathematical formulas.

Table 11. Independent Samples Test Post test

Independent Samples Test					
		t-test for Equality of Means			
				Significance	
		t	df	One-Sided p	Two-Sided p
PostTest Score	Equal variances assumed	2.657	36	.006	.012
	Equal variances not assumed	2.657	35.490	.006	.012

A comparison of the overall measurement results is summarized in Table 12, which shows that the experimental group achieved a higher mean score than the control group. This finding confirms that the integration of the Deep Learning approach with Discovery Learning is more effective than the Cooperative Learning model in improving students' conceptual understanding and formula mastery.

Table 12. Comparison of Measurement Results

Measurement	Average Score (Mean)	
	Experiment Class	Control Class
Pretest	51.7105	50.5263
Posttest	73.684	58.947

These findings indicate that the Deep Learning approach promotes meaningful learning by encouraging students to actively construct knowledge, connect prior knowledge with new concepts, and engage in deeper cognitive processes. The Discovery Learning model further supports this process by providing opportunities for exploration, investigation, and independent concept formation, which enhances students' understanding and retention of mathematical formulas.

In contrast, although the Cooperative Learning model facilitates collaboration and peer interaction, it tends to emphasize group processes rather than individual cognitive engagement, which may limit the development of deep conceptual understanding. As a result, students in the control group are more likely to rely on procedural knowledge rather than fully understanding the underlying concepts of mathematical formulas.

Overall, the results of this study confirm that integrating the Deep Learning approach with the Discovery Learning model is an effective strategy to overcome surface learning tendencies and significantly improve students' mastery of mathematical formulas in elementary mathematics education.

D. Conclusion

This This study concludes that the implementation of the Deep Learning approach through the Discovery Learning model has a significant effect on improving fifth-grade students' mastery of mathematical formulas. The findings show that students in the experimental group achieved higher posttest scores compared to those in the control group, indicating that the applied instructional approach is more effective than the Cooperative Learning model in enhancing students' conceptual understanding.

The results of the statistical analysis further confirm that there is a significant difference between the two groups, demonstrating that the integration of Deep Learning and Discovery Learning successfully promotes deeper cognitive engagement and meaningful learning. This approach enables students to construct their own understanding, connect prior knowledge with new concepts, and apply mathematical formulas more effectively.

Therefore, the Deep Learning approach integrated with the Discovery Learning model can be considered an effective instructional strategy to overcome surface learning tendencies and improve students' mastery of mathematical concepts, particularly in elementary mathematics education. However, it is important to acknowledge certain limitations of this study, specifically regarding the relatively short duration of the treatment and the limited research scope, as the study was conducted in only one elementary school. These limitations may affect the generalizability of the findings to broader educational contexts. Therefore, future research is recommended to extend the duration of the intervention and involve multiple schools from diverse settings in order to obtain more comprehensive and generalizable results.

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