ELEMENTARY: Jurnal Inovasi Pendidikan Dasar
Vol. 7, No. 1, November 2026 – Januari 2027
e-ISSN : 2774-7034 | p-ISSN : 2774-8014
Online Journal System : https://jurnalp4i.com/index.php/elementary

THE EFFECT OF THE DEEP LEARNING APPROACH ON STUDENTS' CRITICAL THINKING AND PROBLEM-SOLVING SKILLS IN MATHEMATICS SUBJECTS AMONG FIFTH-GRADE STUDENTS OF PUBLIC ELEMENTARY SCHOOLS IN PRAYA TENGAH DISTRICT

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Diterima: *6/11/2026*; Direvisi: *18/11/2026*; Diterbitkan: *24/11/2026*

ABSTRAK

Penelitian ini bertujuan untuk menganalisis pengaruh pendekatan *deep learning* terhadap kemampuan berpikir kritis dan kemampuan pemecahan masalah siswa pada mata pelajaran matematika di kelas V Sekolah Dasar Negeri (SDN) Kecamatan Praya Tengah. Secara spesifik, kajian ini menguji pengaruh pendekatan *deep learning* terhadap kemampuan berpikir kritis secara parsial, pengaruhnya terhadap kemampuan pemecahan masalah secara parsial, serta pengaruh keduanya secara simultan. Penelitian menggunakan pendekatan kuantitatif dengan metode eksperimen semu (*quasi-experimental*) melalui desain *nonequivalent control group design* pada 114 siswa kelas V yang terbagi ke dalam kelompok eksperimen dan kelompok kontrol. Kelompok eksperimen memperoleh pembelajaran dengan pendekatan *deep learning*, sedangkan kelompok kontrol memperoleh pembelajaran konvensional, dengan pengumpulan data melalui instrumen tes kemampuan berpikir kritis dan tes kemampuan pemecahan masalah yang dianalisis menggunakan uji *Independent Samples t-test* dan *Multivariate Analysis of Variance* (*MANOVA*) pada *IBM SPSS Statistics*. Hasil penelitian menunjukkan bahwa pendekatan *deep learning* berpengaruh signifikan secara parsial terhadap kemampuan berpikir kritis ($F = 65{,}340$; $p < 0{,}001$) dan kemampuan pemecahan masalah ($F = 58{,}236$; $p < 0{,}001$), serta berpengaruh signifikan secara simultan terhadap kedua kemampuan tersebut (*Wilks' lambda* = 0,496; $F = 56{,}485$; $p < 0{,}001$).

Kata Kunci: *deep learning, kemampuan berpikir kritis, pemecahan masalah siswa*

ABSTRACT

This study aims to analyze the effect of the deep learning approach on students' critical thinking and problem-solving skills in Grade V mathematics at public elementary schools in Praya Tengah District. Specifically, the investigation examines the partial effect of the deep learning approach on critical thinking skills, its partial effect on problem-solving skills, and its simultaneous effect on both cognitive skills. The study employed a quantitative approach with a quasi-experimental method using a nonequivalent control group design involving 114 Grade V students divided into experimental and control groups. The experimental group received instruction using the deep learning approach while the control group received conventional instruction, with data collected through critical thinking and problem-solving tests and analyzed using independent-samples t-tests and multivariate analysis of variance (MANOVA) via IBM SPSS Statistics. The results demonstrate that the deep learning approach exerts a significant partial effect on critical thinking skills ($F = 65.340, p < 0.001$) and problem-solving skills ($F = 58.236, p < 0.001$), as well as a significant simultaneous effect on both skills (*Wilks' lambda* = 0.496, $F = 56.485, p < 0.001$).

Keywords: *deep learning, critical thinking skills, students' problem-solving skills*

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https://doi.org/10.51878/elementary.v7i1.16924

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INTRODUCTION

Mathematics learning at the elementary school level plays a pivotal role in shaping students' cognitive abilities, particularly in logical reasoning, critical thinking, and problem-solving. Mathematics instruction is not merely limited to mastering abstract concepts or computational procedures, but also aims to cultivate students' abilities in interpreting information, selecting strategies, reasoning, and making systematic decisions (Alyusfitri et al., 2023; Siregar et al., 2024). Therefore, mathematics learning must be designed so that students do not solely memorize formulas, but deeply comprehend underlying concepts and apply them in meaningful contexts. Connecting mathematical concepts to real-life experiences enables students to construct meaningful understanding that resonates with their daily lives (Agustin & Rindaningsih, 2022; Pangestika & Cahyaningsih, 2022).

One of the essential competencies that must be nurtured in mathematics learning is critical thinking. This ability is indispensable so that students can interpret information accurately, recognize interconcept relationships, evaluate the validity of a solution, and draw conclusions based on logical considerations (Nurfahrani et al., 2023; Rahardhian, 2022). Through critical thinking skills, students do not passively absorb information, but actively process, question, and weigh evidence before making decisions. In addition, problem-solving skills constitute an inseparable component of mathematics learning because students must understand problems, formulate resolution strategies, execute those strategies, and verify the obtained results (Branca, 1980; Sumartini, 2016). Both cognitive abilities are closely intertwined because solving complex mathematical problems inherently requires analytical reasoning, strategic evaluation, and reflective judgment.

Nevertheless, the development of critical thinking and problem-solving skills among elementary school students still encounters various pedagogical obstacles. Empirical studies reveal that elementary students frequently experience difficulties in grasping mathematical concepts, identifying relevant information, selecting appropriate solution strategies, and articulating logical justifications for their answers (Eriansyah & Baadilla, 2023; Sianturi & Dirgantoro, 2023). One primary cause of this condition stems from teacher-centered instruction that relies heavily on routine exercises. Excessive emphasis on rote memorization and rigid procedural drills restricts students' opportunities to explore ideas, exchange opinions, reflect on their learning processes, and formulate independent problem-solving strategies (Listyana et al., 2022). Consequently, contemporary mathematics instruction must provide broader intellectual space for students to actively engage in higher-order thinking processes.

Various pedagogical efforts have been undertaken through the implementation of more active learning approaches and instructional models. Contextual learning, for instance, offers opportunities for students to connect mathematical concepts with authentic situations encountered in everyday life. Meanwhile, utilizing concrete media and hands-on activities helps elementary school students comprehend mathematical materials that possess abstract characteristics (Budhayanti & Anindyta, 2021; Sutiarso et al., 2021). The problem-based learning model also encourages students to confront non-routine problems, engage in collaborative discussions, process information, and explore multiple potential solutions (Fani & Indarini, 2023). However, effective mathematics instruction must go beyond simply presenting problems by fostering deep conceptual understanding, metacognitive awareness, and positive learning experiences.

One instructional approach that embodies these pedagogical characteristics is the deep learning approach. This approach positions deep conceptual understanding as the core of the learning process by connecting newly acquired knowledge with students' prior knowledge and

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applying that understanding across relevant contexts. This paradigm contrasts sharply with surface learning, which emphasizes passive memorization and mechanical repetition of information. In elementary mathematics instruction, the deep learning approach provides structured opportunities for students to think actively, critically examine information, and construct knowledge through meaningful learning experiences (Suwandi et al., 2024).

The implementation of the deep learning approach is also closely aligned with the competencies required to meet 21st-century educational demands. The instructional process is directed not only toward content mastery, but also toward cultivating critical thinking, creativity, communication, collaboration, and the capacity to apply knowledge to resolve complex real-world problems (Fitriani, 2025). Previous empirical studies indicate that instruction emphasizing deep cognitive processing enhances students' intellectual engagement while fostering richer learning experiences (Paillin et al., 2024). Riyani and Hadi (2023) similarly demonstrate that meaningful learning experiences and active student participation significantly bolster learning motivation and cognitive involvement. Furthermore, Seviardini et al. (2026) empirically report the positive effect of the deep learning approach on enhancing elementary students' critical thinking skills.

In this study, the implementation of the deep learning approach is operationalized through three foundational pillars: meaningful learning, mindful learning, and joyful learning. Meaningful learning guides students to integrate newly introduced mathematical concepts with their existing knowledge and prior experiences so that learning becomes personally relevant (Hafidzhoh et al., 2023). Mindful learning emphasizes students' conscious awareness during the learning process, encouraging them to monitor their cognitive activities and reflect on the knowledge they acquire (Diputera et al., 2024). Meanwhile, joyful learning focuses on cultivating a supportive and emotionally positive classroom atmosphere that stimulates active student participation throughout the lesson (Wijaya et al., 2025). Integrating these three pillars creates a holistic learning experience that values both students' cognitive thinking processes and their final academic outcomes.

The theoretical link between the deep learning approach and students' critical thinking and problem-solving skills is evident in the structure of its learning activities. Through meaningful learning, students are encouraged to relate mathematical problems to authentic experiences within their immediate environment. Mindful learning enables students to regulate their thinking processes, evaluate alternative strategies, and monitor each step of their problem-solving procedures. Simultaneously, joyful learning fosters psychological safety and enthusiasm that sustain student engagement during exploration, peer discussion, and collaborative problem-solving. Previous studies further confirm a strong interconnection between critical thinking and problem-solving skills in mathematics, indicating that both competencies can be cultivated synergistically (Anggreini et al., 2022; Konoras et al., 2022).

Similar instructional challenges are evident in mathematics classrooms across public elementary schools in Praya Tengah District. Based on preliminary observations conducted at several schools—namely SDN 1 Pengadang, SDN Meka, SDN Gerantung, SDN 2 Batu Nyala, SDN 1 Batu Nyala, SDN Dakung, SDN 1 Sanggeng, and SDN 2 Braim—fifth-grade students' critical thinking and problem-solving skills have not yet developed optimally. Ongoing classroom instruction predominantly relies on conventional lecture-based methods, resulting in uneven student participation and limited utilization of learning media beyond standard textbooks. Moreover, learning activities remain heavily oriented toward memorizing formulas and completing routine drills. This empirical reality underscores the urgent need for an

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instructional approach that empowers students to deeply understand concepts, explore non-routine problems, devise strategic solutions, and reflect on their reasoning processes.

Based on the theoretical and empirical considerations outlined above, the deep learning approach represents a highly relevant pedagogical intervention because it prioritizes conceptual depth, active engagement, metacognitive awareness, and meaningful learning experiences. Although prior studies have documented the potential of deep learning in supporting various cognitive outcomes, research specifically investigating its simultaneous impact on critical thinking and problem-solving skills in fifth-grade mathematics within public elementary schools in Praya Tengah District remains scarce. Therefore, this study aims to examine the partial and simultaneous effects of the deep learning approach on fifth-grade students' critical thinking and problem-solving skills in mathematics subjects at public elementary schools in Praya Tengah District.

RESEARCH METHODS

Research Design

This study employed a quantitative approach utilizing a quasi-experimental method with a nonequivalent control group design. The investigation involved two intact classes assigned as an experimental group and a control group. The experimental group received mathematics instruction delivered through the deep learning approach, whereas the control group received conventional classroom instruction. Both groups underwent a pre-test prior to the instructional intervention to establish baseline equivalence and a post-test following the completion of the treatment. The structural layout of the research design is illustrated in Table 1.

Table 1. Research Design

Group	Pre-test	Treatment	Post-test
Experimental	O_1	X	O_2
Control	O_3	–	O_4

Note: X= Instruction using the deep learning approach; O_1, O_3= Pre-test; O_2, O_4= Post-test.

As depicted in Table 1, both the experimental and control groups were administered identical pre-test measurements (O_1 and O_3) before any instructional intervention took place. During the treatment phase, only the experimental group was exposed to the deep learning instructional intervention (X), while the control group continued learning through standard conventional procedures without experimental treatment. Upon concluding the instructional sessions, both groups completed the post-test (O_2 and O_4) to evaluate changes in their cognitive competencies. This design allows for a systematic comparison of post-intervention gains between the two groups while accounting for initial baseline performance.

Population and Sample

The population of this study comprised all fifth-grade students enrolled in public elementary schools in Praya Tengah District, Central Lombok Regency. The research sample was selected using a purposive sampling technique by considering comparable school characteristics, curriculum alignment, and classroom conditions relevant to the research objectives. Based on this selection procedure, a total sample of 114 fifth-grade students participated in the study. The distribution of participants across the experimental and control groups is detailed in Table 2.

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Table 2. Research Sample Distribution

Group	Number of Students	Treatment
Experimental	57	Deep learning approach
Control	57	Conventional instruction
Total	**114**	

Referring to Table 2, the total sample of 114 students was equally divided into 57 students in the experimental group and 57 students in the control group. The experimental group received structured mathematics lessons integrating the deep learning approach, whereas the control group underwent conventional textbook-oriented instruction. Having an equal sample size of 57 participants in each condition strengthens the statistical power and balance required for subsequent comparative and multivariate analyses.

Research Variables

This study investigated the causal relationship between one independent variable and two dependent variables. The independent variable (X) was the instructional approach applied in the classroom, categorized into the deep learning approach for the experimental group and conventional instruction for the control group. The two dependent variables examined were students' critical thinking skills (Y_1) and students' mathematical problem-solving skills (Y_2).

Research Instruments

Data regarding students' critical thinking skills and problem-solving skills were collected using structured essay tests administered during the pre-test and post-test phases. Each test instrument initially comprised 10 essay items during the pilot trial stage. Following empirical item quality analysis and alignment with indicator representation, 5 optimal items were selected for each instrument to be administered in the actual study. Critical thinking skills were measured across four core indicators: interpretation, analysis, evaluation, and inference. Meanwhile, mathematical problem-solving skills were assessed based on four sequential indicators: understanding the problem, devising a plan, carrying out the plan, and looking back. In addition to cognitive tests, structured observation sheets were utilized to monitor the fidelity of the deep learning implementation across three pedagogical pillars: meaningful learning, mindful learning, and joyful learning.

Instrument Quality Test

Prior to classroom administration, the essay test instruments for critical thinking skills and problem-solving skills underwent empirical pilot testing to verify their psychometric quality. The evaluation encompassed item validity, internal consistency reliability, difficulty index, and discriminating power. The validity analysis revealed that the critical thinking pre-test contained 9 valid items and 1 invalid item, whereas all 10 items on the problem-solving pre-test, critical thinking post-test, and problem-solving post-test met the validity criteria. Reliability testing using Cronbach's Alpha confirmed that all four test instruments exceeded the minimum reliability threshold, while difficulty index and discriminating power analyses showed that the items were predominantly in the moderate difficulty and good discrimination categories. The comprehensive psychometric results of the instrument trials are summarized in Table 3.

Table 3. Summary of Instrument Quality Test Results

Instrument	Validity	Cronbach's Alpha (α)	Difficulty Index (p)	Discriminating Power	Items Used
Critical Thinking Skills Pre-test	9 valid, 1 invalid	0.792	0.47 – 0.54 (moderate)	7 good, 2 fair, 1 poor	5

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Problem-Solving Skills Pre-test	10 valid	0.843	0.48 – 0.66 (moderate)	1 very good, 7 good, 2 fair 5
Critical Thinking Skills Post-test	10 valid	0.882	0.45 – 0.59 (moderate)	1 very good, 8 good, 1 fair 5
Problem-Solving Skills Post-test	10 valid	0.848	0.39 – 0.72 (moderate)	1 very good, 7 good, 2 fair 5

As shown in Table 3, all four instruments demonstrated high internal consistency with Cronbach's Alpha values ranging from 0.792 to 0.882, confirming their reliability for research measurement. Out of the 10 trial items in each instrument, 5 items were carefully selected for the pre-test and post-test based on superior statistical validity, moderate difficulty indices (0.39 to 0.72), and good to very good discriminating power. Furthermore, the selection process ensured that every indicator outlined in the critical thinking and problem-solving blueprints was proportionally represented. Consequently, the finalized instruments satisfied both psychometric rigor and content validity standards.

Research Procedure

The research procedure was systematically executed across three sequential phases. In the initial phase, students' baseline competencies in critical thinking and problem-solving were measured by administering the pre-test to both the experimental and control groups. During the second phase, the experimental group received a structured instructional intervention spanning six classroom meetings utilizing the deep learning approach. This intervention integrated three active instructional models: Problem-Based Learning (PBL) during the first and second meetings, Discovery Learning during the third and fourth meetings, and Project-Based Learning (PjBL) during the fifth and sixth meetings. Throughout all six sessions, the principles of meaningful learning, mindful learning, and joyful learning were embedded into classroom activities and monitored via observation sheets. In the final phase, a post-test was administered to both groups to measure cognitive gains resulting from the instructional treatment.

Data Analysis Technique

All collected quantitative data were processed using IBM SPSS Statistics through both descriptive and inferential statistical procedures. Prior to testing the research hypotheses, parametric prerequisite tests were conducted, comprising univariate normality tests, multivariate normality assessment, homogeneity of variances via Levene's Test, and homogeneity of variance-covariance matrices using Box's M Test. Partial hypothesis testing was performed using Independent Samples t-tests to examine mean differences between the experimental and control groups on each dependent variable separately. Additionally, Multivariate Analysis of Variance (MANOVA) was applied to evaluate the simultaneous effect of the deep learning approach on critical thinking and problem-solving skills at a significance level of $\alpha = 0.05 (p < 0.05)$.

RESULTS AND DISCUSSION

Results

Pre-test Results

A pre-test was administered prior to the instructional intervention to assess the baseline equivalence of students' initial cognitive abilities in both groups. Descriptive statistics—including sample size (N), mean, and standard deviation—were computed for critical thinking

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e-ISSN : 2774-7034 | p-ISSN : 2774-8014
Online Journal System : https://jurnalp4i.com/index.php/elementary

skills (CTS) and problem-solving skills (PSS). The pre-test descriptive statistics for the control and experimental groups are presented in Table 4.

Table 4. Pre-test Descriptive Statistics

Group	Variable	*N*	Mean	Standard Deviation
Control	CTS	57	44.56	9.272
Control	PSS	57	45.79	9.053
Experimental	CTS	57	44.56	9.077
Experimental	PSS	57	48.60	9.249

Based on Table 4, the average initial critical thinking skills (CTS) score was identical in both the control and experimental groups at 44.56, with comparable standard deviations of 9.272 and 9.077, respectively. For problem-solving skills (PSS), the control group recorded a baseline mean of 45.79 ($SD = 9.053$), whereas the experimental group obtained a slightly higher baseline mean of 48.60 ($SD = 9.249$). Overall, these descriptive figures confirm that students in both groups possessed relatively equivalent and low-to-moderate baseline cognitive skills prior to receiving the instructional treatment.

Implementation of the Deep Learning Approach

The instructional intervention in the experimental group was conducted across six consecutive meetings in two participating elementary schools. The deep learning approach was operationalized through Problem-Based Learning (PBL) in the first and second meetings, Discovery Learning in the third and fourth meetings, and Project-Based Learning (PjBL) in the fifth and sixth meetings. Classroom observations were recorded at every session to evaluate adherence to meaningful learning, mindful learning, and joyful learning principles, as summarized in Table 5.

Table 5. Implementation of the Deep Learning Approach

Meeting	Learning Model	School 1	School 2	Category
1	PBL	95%	83%	Very Good
2	PBL	86%	86%	Very Good
3	Discovery Learning	91%	88%	Very Good
4	Discovery Learning	86%	88%	Very Good
5	PjBL	85%	93%	Very Good
6	PjBL	95%	83%	Very Good

As shown in Table 5, the implementation fidelity of the deep learning approach across all six meetings in both School 1 and School 2 consistently fell within the "Very Good" category, with percentages ranging from 83% to 95%. Specifically, School 1 achieved its highest implementation scores of 95% during the first and sixth meetings, while School 2 reached its peak implementation score of 93% during the fifth meeting. These consistently high observation scores verify that the three pillars of deep learning—meaningful, mindful, and joyful learning—were faithfully and effectively executed throughout the instructional intervention.

Post-test Results

Following the completion of the six-meeting instructional intervention, a post-test was administered to both the experimental and control groups to measure improvements in students' critical thinking skills (CTS) and problem-solving skills (PSS). Descriptive statistical metrics were calculated to compare post-intervention performance across both conditions. The post-test descriptive statistics are detailed in Table 6.

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e-ISSN : 2774-7034 | p-ISSN : 2774-8014
Online Journal System : https://jurnalp4i.com/index.php/elementary

Table 6. Post-test Descriptive Statistics

Group	Variable	*N*	Mean	Standard Deviation
Control	CTS	57	66.67	9.129
Control	PSS	57	67.72	8.968
Experimental	CTS	57	80.18	8.710
Experimental	PSS	57	80.26	8.578

According to the post-test data in Table 6, the experimental group achieved a substantially higher average critical thinking skills (CTS) score of 80.18 ($SD = 8.710$) compared to the control group's mean score of 66.67 ($SD = 9.129$). Similarly, on the problem-solving skills (PSS) post-test, the experimental group attained a mean score of 80.26 ($SD = 8.578$), outperforming the control group, which recorded a mean score of 67.72 ($SD = 8.968$). These descriptive comparisons indicate that students taught using the deep learning approach experienced markedly greater cognitive gains than those receiving conventional instruction.

Prerequisite Analysis Test Results

Before conducting parametric hypothesis testing, statistical prerequisite evaluations were performed to verify univariate normality, homogeneity of variances, multivariate normality, and homogeneity of covariance matrices. Univariate normality was assessed across pre-test and post-test scores for both groups using the Kolmogorov-Smirnov test. The results of the univariate normality analysis are displayed in Table 7.

Table 7. Normality Test Results

Variable	Group	Pre-test *Sig.*	Post-test *Sig.*
CTS	Control	0.570	0.530
CTS	Experimental	0.550	0.640
PSS	Control	0.640	0.810
PSS	Experimental	0.750	0.530

As presented in Table 7, all significance values (*Sig.*) across both pre-test and post-test distributions for CTS and PSS exceeded the 0.05 threshold, ranging from 0.530 to 0.810. These results confirm that the univariate data distributions in both the control and experimental groups did not deviate significantly from normality. Consequently, the univariate normality assumption for parametric statistical analysis was fully satisfied.

Subsequently, homogeneity of variances between the experimental and control groups was examined using Levene's Test across both pre-test and post-test scores. Establishing variance homogeneity ensures that group comparisons are not distorted by unequal error variances. The outcomes of the homogeneity of variance tests are reported in Table 8.

Table 8. Homogeneity Test Results

Variable	Pre-test *Sig.*	Post-test *Sig.*
CTS	0.865	0.602
PSS	0.802	0.644

Referring to Table 8, the significance values obtained from Levene's Test were 0.865 (pre-test) and 0.602 (post-test) for CTS, as well as 0.802 (pre-test) and 0.644 (post-test) for PSS. Because all significance values substantially exceeded the 0.05 criterion, the error variances across the experimental and control groups were confirmed to be homogeneous.

To fulfill the specific requirements of multivariate analysis, multivariate normality was evaluated by inspecting the scatter plot between Mahalanobis Distance and Chi-Square values. Visual inspection of the distribution pattern verifies whether the joint distribution of the dependent variables conforms to multivariate normality. The scatter plot generated from this diagnostic test is shown in Figure 1.

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e-ISSN : 2774-7034 | p-ISSN : 2774-8014
Online Journal System : https://jurnalp4i.com/index.php/elementary

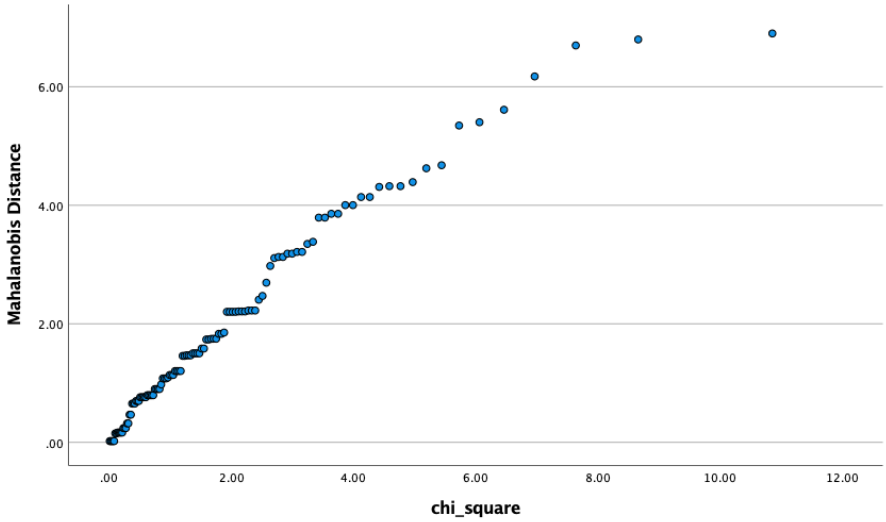

Figure 1. Scatter Plot of Mahalanobis Distance and Chi-Square

As illustrated in Figure 1, the plotted data points align closely along a linear diagonal trajectory, demonstrating a strong linear correlation between Mahalanobis Distance and Chi-Square quantiles. This linear alignment confirms that the dataset satisfies the multivariate normality assumption required for MANOVA. In addition, the homogeneity of variance-covariance matrices was tested using Box's M Test, yielding a Box's M value of 4.516 with $F = 1.476$ and a significance value of 0.219 ($p > 0.001$), thereby confirming that the covariance matrices across groups are homogeneous.

Hypothesis Test Results

Following the satisfaction of all parametric assumptions, partial hypothesis testing was conducted using Independent Samples t-tests to determine whether statistically significant differences existed between the experimental and control groups on each dependent variable. The analytical outputs of the Independent Samples t-tests are presented in Table 9.

Table 9. Independent Samples t-test Results

Variable	*t*	*df*	*Sig.*	Control Mean	Experimental Mean
CTS	-8.083	112	< 0.001	66.67	80.18
PSS	-7.631	112	< 0.001	67.72	80.26

Based on Table 9, the Independent Samples t-test for critical thinking skills (CTS) yielded $t = -8.083$ ($df = 112$) with a significance value of $p < 0.001$, indicating a statistically significant difference favoring the experimental group ($M = 80.18$) over the control group ($M = 66.67$). Similarly, the test for problem-solving skills (PSS) produced $t = -7.631 (df = 112)$ with $p < 0.001$, demonstrating that the experimental group ($M = 80.26$) significantly outperformed the control group ($M = 67.72$). These findings confirm that the deep learning approach exerts a significant positive partial effect on both critical thinking and problem-solving skills.

To evaluate the simultaneous effect of the deep learning approach on critical thinking skills and problem-solving skills concurrently, a Multivariate Analysis of Variance (MANOVA) was executed using *Wilks' lambda* statistics. Examining both dependent variables jointly accounts for their intercorrelation and provides a comprehensive test of the intervention's overall cognitive impact. The multivariate test results are summarized in Table 10.

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e-ISSN : 2774-7034 | p-ISSN : 2774-8014
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Table 10. MANOVA Results

Effect	*Wilks' lambda*	*F*	df_1	df_2	*Sig.*
Deep Learning	0.496	56.485	2	111	< 0.001

As reported in Table 10, the MANOVA analysis yielded a *Wilks' lambda* value of 0.496 with $F(2,111) = 56.485$ and a significance value of $p < 0.001$ (smaller than the 0.05 threshold). The low *Wilks' lambda* value indicates that a substantial proportion of variance in the combined dependent variables is explained by the instructional treatment. Thus, the deep learning approach is proven to exert a statistically significant simultaneous effect on fifth-grade students' critical thinking and problem-solving skills in mathematics.

Discussion

1. The Effect of the Deep Learning Approach on Critical Thinking Skills

Based on the statistical analysis, the implementation of the deep learning approach is proven to exert a significant positive impact on enhancing fifth-grade students' critical thinking skills. This improvement is evidenced by the experimental group's post-test mean score of 80.18, which substantially outperformed the control group's mean of 66.67, supported by a statistically significant t-test result ($t = -8.083, p < 0.001$). These empirical findings align closely with the core pedagogical principles of deep learning, which prioritize conceptual depth, metacognitive awareness, and active student participation over passive rote memorization.

In accordance with Siregar et al. (2025), applying the deep learning approach in mathematics education integrates three foundational pillars: meaningful learning, mindful learning, and joyful learning. This pedagogical synergy encourages students not merely to receive knowledge transmission, but to connect mathematical concepts with real-world contexts, regulate their thinking processes, and engage actively in classroom discourse. A similar conclusion is advanced by Lubis and Ramlah (2025), who emphasize that the reflective, contextual, and student-centered characteristics of deep learning effectively stimulate metacognitive development. Furthermore, Siregar et al. (2026) confirm that integrating mindful, meaningful, and joyful learning strengthens elementary students' critical reasoning capacities, particularly when operationalized through active models such as Problem-Based Learning, Discovery Learning, and Project-Based Learning.

2. The Effect of the Deep Learning Approach on Problem-Solving Skills

The implementation of the deep learning approach also demonstrated a statistically significant positive effect on improving students' mathematical problem-solving skills. Students in the experimental group attained a post-test mean score of 80.26, surpassing the control group's average score of 67.72, with an Independent Samples t-test value of $t = -7.631 (p < 0.001)$. This substantial gain reflects the effectiveness of structured instructional activities that train students to analyze non-routine contextual problems and systematically formulate resolution strategies.

According to Sianturi and Dirgantoro (2023), mathematical problem-solving encompasses sequential cognitive stages: understanding problem constraints, designing a strategic plan, executing the solution, and evaluating the final outcome. This problem-solving cycle aligns seamlessly with the deep learning approach, which guides learners to investigate mathematical structures deeply and engage in continuous self-reflection. These findings are further corroborated by Nurjannah and Ramlah (2025), whose systematic review establishes that deep learning enhances mathematical problem-solving abilities through active, reflective, collaborative, and contextualized learning tasks. Bambang et al. (2025) similarly report that the deep learning approach significantly elevates students' problem-solving performance compared to conventional instruction.

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https://doi.org/10.51878/elementary.v7i1.16924

ELEMENTARY: Jurnal Inovasi Pendidikan Dasar
Vol. 7, No. 1, November 2026 – Januari 2027
e-ISSN : 2774-7034 | p-ISSN : 2774-8014
Online Journal System : https://jurnalp4i.com/index.php/elementary

3. The Effect of the Deep Learning Approach on Critical Thinking and Problem-Solving Skills Simultaneously

The multivariate hypothesis testing via MANOVA yielded a *Wilks' lambda* value of 0.496 with $F(2,111) = 56.485$and $p < 0.001$, confirming a significant simultaneous effect of the deep learning approach on students' critical thinking and problem-solving skills. Conceptually, the simultaneous enhancement of both cognitive competencies is anchored in the principle of meaningful learning, which bridges students' prior mathematical knowledge with newly encountered concepts. Hafidzhoh et al. (2023) emphasize that meaningful learning is essential for constructing a coherent and durable framework of conceptual understanding. Fitriani (2025) similarly notes that integrating new information with existing cognitive structures enables learners to build more complex and adaptable mental schemas.

Moreover, delivering the deep learning approach through Problem-Based Learning, Discovery Learning, and Project-Based Learning systematically engages students in identifying authentic problems, analyzing data, evaluating alternative strategies, and reflecting on their solutions. This integrated sequence of cognitive activities stimulates analytical reasoning and strategic problem-solving concurrently rather than in isolation. These multivariate findings align with Siregar et al. (2026) and Nurjannah and Ramlah (2025), who demonstrate that the reflective, contextual, and student-centered nature of deep learning simultaneously fosters higher-order critical thinking and mathematical problem-solving competencies among elementary learners.

CONCLUSION

Based on the empirical findings and statistical analyses, it can be concluded that the implementation of the deep learning approach exerts a statistically significant positive effect on fifth-grade students' critical thinking skills and mathematical problem-solving skills at public elementary schools in Praya Tengah District. Partially, students instructed through the deep learning approach achieved significantly higher post-test scores in critical thinking skills ($M = 80.18$ vs. $M = 66.67$; $t = -8.083, p < 0.001$) and problem-solving skills ($M = 80.26$ vs. $M = 67.72$; $t = -7.631, p < 0.001$) than those taught using conventional methods. Furthermore, MANOVA results confirm a significant simultaneous effect of the deep learning approach on both cognitive competencies concurrently (*Wilks' lambda* = 0.496, $F(2,111) = 56.485, p < 0.001$). Consequently, integrating meaningful, mindful, and joyful learning principles into elementary mathematics instruction is strongly recommended to cultivate students' higher-order thinking and problem-solving capabilities.

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https://doi.org/10.51878/elementary.v7i1.16924

ELEMENTARY: Jurnal Inovasi Pendidikan Dasar
Vol. 7, No. 1, November 2026 – Januari 2027
e-ISSN : 2774-7034 | p-ISSN : 2774-8014
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