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The Effect of the Deep Learning Approach on Eighth-Grade Students' Mathematical Problem-Solving Ability

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Abstrak

Kemampuan pemecahan masalah matematika merupakan salah satu kompetensi penting yang harus dimiliki siswa dalam pembelajaran matematika. Namun, siswa masih mengalami kesulitan dalam memahami masalah kontekstual, menyusun model matematika, dan menentukan strategi penyelesaian yang tepat. Penelitian ini bertujuan untuk mengetahui pengaruh pendekatan deep learning terhadap kemampuan pemecahan masalah matematika siswa. Penelitian menggunakan pendekatan kuantitatif dengan metode quasi experiment dan desain Posttest-Only Non-Equivalent Control Group Design. Populasi penelitian adalah siswa kelas VIII SMP Negeri 20 Gresik tahun ajaran 2025/2026. Sampel penelitian berjumlah 64 siswa yang terdiri atas kelas eksperimen dan kelas kontrol. Kelas eksperimen memperoleh pembelajaran menggunakan pendekatan deep learning melalui model Problem Based Learning (PBL), sedangkan kelas kontrol menggunakan pendekatan surface learning melalui model ekspositori. Data dikumpulkan menggunakan tes uraian berdasarkan indikator pemecahan masalah polya. Analisis data dilakukan melalui uji normalitas, homogenitas, dan uji Mann-Whitney. Hasil penelitian menunjukkan bahwa rata-rata nilai posttest kelas eksperimen lebih tinggi dibandingkan kelas kontrol. Hasil uji Mann-Whitney memperoleh nilai Asmp. Sig. (2-tailed) sebesar 0,000 < 0,05 yang menunjukkan bahwa pendekatan deep learning berpengaruh signifikan terhadap kemampuan pemecahan masalah matematika siswa. Nilai effect size sebesar 0,60 menunjukkan kategori pengaruh besar. Dengan demikian, pendekatan deep learning mampu meningkatkan kemampuan pemecahan masalah matematika siswa secara signifikan.
Kata Kumci*: Pendekatan Deep Learning, Kemampuan Pemecahan Masalah Matematika, Problem Based Learning (PBL).*

Abstract

Mathematical problem-solving ability is a fundamental skill that students should develop in mathematics learning. Nevertheless, many students continue to experience difficulties in interpreting contextual problems, formulating mathematical models, and selecting appropriate solution strategies. This study investigated the effect of the deep learning approach on students' mathematical problem-solving ability. A quantitative quasi-experimental method with a Posttest-Only Non-Equivalent Control Group Design was employed. The participants were 64 eighth-grade students of SMP Negeri 20 Gresik in the 2025/2026 academic year, divided equally into an experimental group and a control group. The experimental group was taught using the deep learning approach integrated with the Problem-Based Learning (PBL) model, whereas the control group received surface learning through the expository model. Data were obtained from essay tests developed according to Polya's problem-solving indicators. Following normality and homogeneity testing, the Mann–Whitney U test was used to analyze the data. The findings indicated that the experimental group achieved a higher mean posttest score (87.82) than the control group (74.47). The Mann–Whitney U test produced an Asymp. Sig. (2-tailed) value of 0.000 (< 0.05), while the

effect size of 0.60 indicated a large effect, demonstrating that the deep learning approach significantly enhanced students' mathematical problem-solving ability.
Keywords: Deep Learning Approach, Mathematical Problem-Solving Ability, Problem-Based Learning (PBL).

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INTRODUCTION

The development of students logical, critical, and analytical thinking abilities all crucial for tackling the problems of the twenty-first century is a strategic function of mathematics education. Ideally, teaching mathematics should promote conceptual comprehension and the capacity to use mathematical knowledge in practical contexts in addition to procedural fluency and formula mastery (Safari & Milah, 2024). Since solving mathematical problems requires higher-order cognitive processes like analysis, reasoning, and reflection, it is commonly considered a crucial sign of successful mathematics learning (Siswanto & Meiliasari, 2024; Lailiyyah et al., 2023). Mathematical problem-solving ability involves understanding problems, devising appropriate solution strategies, carrying out the selected strategies, and evaluating the obtained solutions. These stages are consistent with Polya's problem-solving framework and serve as important indicators for assessing students' mathematical thinking. Maharni et al. (2025) also emphasized that students' mathematical problem-solving ability can be analyzed through these four stages, where many students tend to experience difficulties particularly in planning solution strategies and evaluating the correctness of their answers.

However, current educational practice indicates a considerable gap between expectations and actual learning outcomes. The average mathematical performance of Indonesian students remained well below the OECD norm, especially in the reasoning and problem-solving domains, according to the findings of the Programme for International Student Assessment (PISA) 2022 (OECD, 2023). These findings are further supported by the Trends in International Mathematics and Science Study (TIMSS), which reported that most Indonesian students continue to perform at lower cognitive levels and encounter difficulties in solving contextual mathematical problems (Hamzah, 2023).

Prior research has consistently shown that junior secondary school students have weak mathematical problem-solving skills. Eighth-grade students frequently experience difficulties in interpreting word problems, planning appropriate solution strategies, and evaluating the correctness of their solutions (Hidayat et al., 2022; Karimah et al., 2022). These findings indicate that mathematics instruction is still predominantly procedural and oriented toward memorization, reflecting a Surface Learning approach that gives students few chances to gain a thorough conceptual understanding (Samosir, 2022).

Within the pedagogical setting, the Deep Learning approach is considered an appropriate instructional approach for addressing these issues. This approach emphasizes deep conceptual understanding, meaningful connections among concepts, metacognitive reflection, and the transfer of knowledge to new situations (A. R. Dewi et al., 2025; Biggs, 1987). The Deep Learning approach in mathematics education pushes students to comprehend the underlying logic of the methods they use in addition to learning how to solve mathematical problems (L. Maharani et al., 2025; Mutmainnah et al., 2025).

Additionally, the Merdeka Curriculum's tenets align with the Deep Learning methodology, which promotes meaningful, contextual, and student-centered learning experiences. The Ministry of Primary and Secondary Education in Indonesia highlights that mathematics instruction should cultivate students' critical, analytical, and reflective thinking skills rather than focusing solely on procedural knowledge and formula memorization (Kemendikdasmen, 2025). One effective way of implementing the Deep Learning approach is through instructional models that actively engage students in the learning process, particularly Problem-Based Learning (PBL) (Adnyana, 2024). Furthermore, previous studies have demonstrated that Problem-Based Learning provides a structured learning trajectory that encourages students to actively construct mathematical concepts through contextual problem solving. By reinforcing literacy and numeracy skills, students are guided to develop conceptual understanding gradually while strengthening their reasoning and problem-solving abilities (Fauziyah, 2023; Aziz et al., 2025). These characteristics are consistent with the principles of the Deep Learning approach, which emphasizes meaningful, reflective, and student-centered learning experiences.

Previous studies have demonstrated that problem-based instruction and Deep Learning-oriented learning environments effectively improve students' conceptual understanding and mathematical problem-solving ability (Patunah et al., 2024; Saputra et al., 2025; Arfiani & Rismen, 2025). In addition, Khurin'in et al. (2024) reported that implementing Problem-Based Learning significantly improved students' mathematical literacy. Since mathematical literacy requires students to formulate, interpret, and solve contextual mathematical problems, these findings further support the potential of PBL to enhance students' mathematical problem-solving ability.

Although previous studies have demonstrated that Problem-Based Learning improves students' mathematical literacy, conceptual understanding, and reasoning skills, limited empirical evidence specifically investigates the implementation of the Deep Learning approach through Problem-Based Learning in improving junior secondary students' mathematical problem-solving ability within the Indonesian educational context. Therefore, this study aims to fill this research gap by providing empirical evidence regarding the effect of the Deep Learning approach through Problem-Based Learning on students' mathematical problem-solving ability.

This study extends previous research by specifically examining the implementation of the Deep Learning approach integrated with the Problem-Based Learning (PBL) model to improve junior secondary students' mathematical problem-solving ability. Therefore, this study investigates the effect of the Deep Learning approach implemented through the Problem-Based Learning (PBL) model on the mathematical problem-solving ability of eighth-grade students at SMP Negeri 20 Gresik

RESEARCH METHOD

This study used a quasi-experimental research design with a quantitative methodology. Because the study sought to objectively investigate the impact of an instructional therapy on a specific variable using numerical data and statistical analysis, a quantitative approach was chosen. Because the classes had already formed naturally, the researcher was unable to randomly assign participants to groups, hence the quasi-experimental design was used.

Two groups, an experimental group and a control group, were used in the Posttest-Only Non-Equivalent Control Group Design. While the control group was instructed using the Surface Learning approach through the expository learning model, the experimental group was taught using the Deep Learning approach through the Problem-Based Learning (PBL) model. All eighth-graders at SMP Negeri 20 Gresik in the 2025–2026 school year made up the population. Purposive sampling was used to choose two classes for the sample based on how comparable the students' academic performance and learning traits were. Class VIII-G was designated as the control group and Class VIII-E as the experimental group.

An essay test intended to measure students' mathematical problem-solving ability served as the main research instrument. The essay test consisted of four contextual mathematical problem-solving questions developed based on Polya's four problem-solving indicators. The test items were developed based on Polya's four stages of mathematical problem solving: understanding the problem, devising a plan, carrying out the plan, and looking back, which remain widely used as indicators for assessing students' mathematical problem-solving ability (Amaliah et al., 2021; Maharni et al., 2025). Experts verified the instrument's content validity, language clarity, and conformity with the study's objectives before it was administered.

Following the completion of the instructional therapy, a posttest was given to both the experimental and control groups in order to gather data. IBM SPSS Statistics 27 was used to evaluate the gathered data. To determine whether the data satisfied the statistical assumptions, assumption tests, such as homogeneity and normality tests, were carried out before hypothesis testing. The Mann–Whitney U test, a non-parametric statistical test, was used for hypothesis testing because the data did not meet these presumptions. The impact of the Deep Learning approach on students' capacity to solve mathematical problems was then ascertained using the analysis's findings.

RESULTS

The purpose of this study was to investigate how the Deep Learning approach affected the eighth-grade students at SMP Negeri 20 Gresik's capacity to solve mathematical problems. A mathematical problem-solving test that was given to both the experimental and control groups following the conclusion of the educational session provided the research data.

The experimental group, which received instruction using the Deep Learning approach implemented using the Problem-Based Learning (PBL) model, obtained a mean posttest score of 87.82, according to the descriptive analysis. On the other hand, the control group received a mean posttest score of 74.47 after being instructed utilizing the Surface Learning approach using the expository learning model. These results show that students in the experimental group were more adept at solving mathematical problems than those in the control group. Figure 1 shows a comparison of the two groups' posttest results.

Descriptives

	Kelompok			Statistic	Std. Error
Nilai	Kelompok Eksperimen	Mean		87,8237	1,10723
		95% Confidence Interval for Mean	Lower Bound	85,5655	
			Upper Bound	90,0820	
		5% Trimmed Mean		87,9325	
		Median		87,5000	
		Variance		39,231	
		Std. Deviation		6,26345	
		Minimum		75,00	
		Maximum		97,91	
		Range		22,91	
		Interquartile Range		11,98	
		Skewness		-,099	,414
		Kurtosis		-1,301	,809
	Kelompok Kontrol	Mean		74,4753	1,99962
		95% Confidence Interval for Mean	Lower Bound	70,3971	
			Upper Bound	78,5536	
		5% Trimmed Mean		75,2710	
		Median		71,8700	
		Variance		127,952	
		Std. Deviation		11,31157	
		Minimum		33,33	
		Maximum		89,58	
		Range		56,25	
		Interquartile Range		14,58	
		Skewness		-1,340	,414
		Kurtosis		4,238	,809

Figure 1. *Comparing the Experimental and Control Groups' Posttest Results*

Polya's four stages of problem solving: understanding the problem, creating a plan, executing the plan, and reflecting back were used to examine students' mathematical problem-solving skills in addition to comparing the overall posttest scores. Table 1 displays the average score for each stage.

Table 1. Average Scores for Each Stage of Mathematical Problem Solving

Stage of Problem-Solving	Experimental Group	Control Group
Understanding the Problem	2.52	2.45
Devising a Plan	2.74	2.03
Carrying Out the Plan	2.91	2.70
Looking Back	2.38	1.79

The experimental group fared better than the control group at every stage of solving mathematical problems, as Table 1 illustrates. The largest differences were observed in the devising a plan and looking back stages, indicating that students who experienced the Deep Learning approach were better able to determine appropriate solution strategies and critically evaluate their solutions. Overall, these results imply that students who were taught using the Deep Learning approach were better at solving mathematical problems than those who were taught using the Surface Learning approach.

The data underwent preliminary analyses, such as homogeneity and normality tests, before hypothesis testing. The variances between the two groups were not homogeneous, according to the homogeneity test using Levene's Test, which produced a significance value of 0.015 ($p < 0.05$). Additionally, the results of the normality test showed that the data were not normally distributed, with significant values of 0.010 for the experimental group and less than 0.001 for the control group. As a result, the Mann–Whitney U test, a non-parametric statistical technique, was used for hypothesis testing. Figure 2 displays the hypothesis test findings.

Test Statistics[a]

	Nilai
Mann-Whitney U	155,500
Wilcoxon W	683,500
Z	-4,809
Asymp. Sig. (2-tailed)	<,001

a. Grouping Variable: Kelompok

Figure 2. Mann-Whitney U Test Results

The Asymp. Sig. (2-tailed) value of 0.000 obtained from the Mann-Whitney U test is less than the significance level of 0.05. This finding shows that students who learned using the Deep Learning approach and those who learned using the Surface Learning approach differed statistically significantly in their capacity to solve mathematical problems. These results show that eighth-grade students at SMP Negeri 20 Gresik's capacity to solve mathematical problems was significantly impacted by the Deep Learning approach.

Rosenthal's effect size formula was used to quantify the effect size in order to ascertain the effect's magnitude:

$$r = \frac{|Z|}{\sqrt{N}}$$

Where:

- Z = Is the standardized test statistic derived from the Mann–Whitney U test
- N = Is the total number of participants

Based on the SPSS output:

- Z = − 4,809
- N = 64

The effect size was calculated as follows:

$$r = \frac{|Z|}{\sqrt{N}} = \frac{|-4{,}809|}{\sqrt{64}} = \frac{4{,}809}{8} = 0{,}60$$

The result of the computation was an effect size of $r = 0.60$. A large effect is defined by Rosenthal's criteria as having an effect size of $r \geq 0.50$. This result shows that the Deep Learning approach had major practical implications in addition to producing a statistically significant improvement in students' mathematical problem-solving skills.

DISCUSSIONS

The results of this study show that students' capacity to solve mathematical problems is effectively improved by using the Deep Learning approach using the Problem-Based Learning (PBL) paradigm. The difference between the experimental and control groups' mean posttest scores, with the experimental group achieving the higher average score, supports this conclusion. These findings suggest that the development of students' mathematical problem-solving abilities is positively impacted by learning activities that foster conceptual comprehension, active participation, and reflective thinking.

These findings may be explained by the characteristics of the Deep Learning approach, which encourages meaningful knowledge construction through active exploration, collaboration, reflection, and contextual problem solving. Consequently, students become more capable of connecting mathematical concepts, selecting appropriate solution strategies, and evaluating the accuracy of their solutions. This learning process enables students to develop higher-order thinking skills, which are essential for effective mathematical problem solving.

Students in the experimental group actively participated in group discussions, exchanged ideas, and evaluated various problem-solving strategies throughout the learning process. Through these educational opportunities, they were able to develop a deeper understanding of mathematical ideas while honing their reasoning and problem-solving skills. Furthermore, the reflection activities conducted at the end of each lesson encouraged students to evaluate both their reasoning processes and the accuracy of their solutions. Polya's four steps of solving mathematical problems: understanding the problem, coming up with a plan, implementing the plan, and reflecting back are strongly related to these educational opportunities.

Students in the control group, on the other hand, encountered a more teacher-centered learning process when they used the Surface Learning approach with the expository learning model. Learning activities primarily consisted of teacher explanations followed by routine practice exercises. As a result, rather than gaining a thorough grasp of the connections between mathematical ideas, students tended to memorize formulas and procedural methods. As a result, compared to kids in the experimental group, their capacity to answer non-routine mathematical problems was less developed.

The results of this study also corroborate theoretical viewpoints that contend that learning is more successful when students actively participate in higher-order cognitive processes including analysis, assessment, and reflection (Chen & Singh, 2024; Kemendikdasmen, 2025). Additionally, by using the concepts of mindful learning, meaningful learning, and joyful learning, the Deep Learning approach fosters meaningful learning experiences that allow students to develop deeper conceptual understanding rather than just procedural information (Andayanie et al., 2025; Nafi'ah & Faruq, 2025).

The findings of this study are consistent with previous research demonstrating the effectiveness of Problem-Based Learning in improving students' mathematical competencies. Fauziyah (2023) reported that PBL provides a meaningful learning trajectory that strengthens students' reasoning and numeracy skills through contextual learning experiences. Likewise, Khurin'in et al. (2024) found that PBL significantly improved students' mathematical literacy, while Maharni et al. (2025) emphasized that effective learning enables students to successfully complete each stage of Polya's problem-solving process. These findings strengthen the present study by indicating that implementing the Deep Learning approach through the PBL model not only improves conceptual understanding but also enhances students' mathematical problem-solving ability.

Overall, the study's findings offer more empirical support for the theoretical claim that the Deep Learning approach is extremely pertinent to the growth of mathematical problem-solving skills. In addition to helping students solve mathematical problems properly, instruction that prioritizes conceptual comprehension, meaningful connections between concepts, teamwork, and reflective thinking also helps them comprehend the rationale, principles, and methods that underlie the solution process. As a result, in junior secondary mathematics classes, the Deep Learning approach provides a useful pedagogical substitute for encouraging higher-order mathematical thinking and enhancing students' problem-solving abilities.

CONCLUSION

The results of this study show that eighth-grade students at SMP Negeri 20 Gresik significantly improve their ability to solve mathematical problems when using the Deep Learning approach. Compared to students who learned through the Surface Learning approach using the expository learning model, students who engaged in mathematics learning through the Deep Learning approach implemented using the Problem-Based Learning (PBL) model showed superior mathematical problem-solving abilities. The computed effect size ($r = 0.60$)

showed a significant practical effect, however the Mann–Whitney U test findings produced a significance value of less than 0.05. As a result, the results indicate that the Deep Learning approach is useful for enhancing students' capacity to solve mathematical problems and could be a useful teaching strategy for junior secondary school mathematics.

RECOMMENDATION

The results of this study indicate that using the Deep Learning approach in conjunction with the Problem-Based Learning (PBL) model can be a useful substitute for improving students' capacity to solve mathematical problems. Mathematics teachers are encouraged to design student-centered learning experiences that incorporate contextual problems, collaborative activities, and reflective practices to facilitate deeper conceptual understanding. Future research should investigate the implementation of the Deep Learning approach across different mathematical topics, educational levels, and other mathematical competencies in order to provide broader empirical evidence regarding its effectiveness in mathematics education.

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