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The Impact of Deep Learning Approach on Student`s Cognitive Abilities in Penerokan

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ABSTRACT

Traditional teacher-centered instruction often hinders the development of critical thinking, leading to poor cognitive outcomes. At SD 48/1 Penerokan, only 8 of 28 students achieved learning mastery. The purpose of the study was to determine the influence of deep learning learning on the cognitive improvement of students in elementary school. Using a quasi-experimental post-test only control group design, the study compared an experimental class using deep learning with a control group. Results showed the experimental group averaged 74.80, significantly higher than the control group's 67.20. A t-test confirmed a significant difference (0.037 < 0.05). Thus, the deep learning approach effectively enhances students' cognitive abilities.

Keywords: *Deep Learning, Cognitive Abilities, Elementary School Learning*

INTRODUCTION

The cognitive abilities of students, which form the foundation for their academic growth and future lives, are greatly influenced by primary education. Critical thinking, problem-solving, conceptual understanding, and the ability to store and absorb information all fall under cognitive abilities (Rahmawati *et al.*, 2024). Learning in elementary schools still tends to use a teacher-centered approach, which provides little room for students to develop and maximize their critical thinking abilities.

The instructor is the main source of knowledge and the student is only a passive recipient of it, according to the traditional teacher-centered approach to education. However, there has been a paradigm change in recent years toward student-centered learning, which places an emphasis on students' active involvement in the educational process. Despite this change, students' cognitive capacities during the learning process are still frequently underdeveloped, especially when it comes to critical thinking, conceptual understanding, and problem-solving ability (Alam, 2023). The deep learning technique is one of the more creative and student-centered learning strategies needed to enhance students' cognitive abilities in light of the evolving times and demands of 21st-century education.

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Because it promotes a more meaningful, critical learning process and the capacity to adjust to swift global change, the deep learning approach is a response to the difficulties of 21st-century basic education. Meaningful cognitive engagement through conceptual comprehension, critical thinking, and the capacity to transfer knowledge across contexts is emphasized by the deep learning approach. Surface learning, on the other hand, concentrates on mechanical memorizing. Because it emphasizes in-depth conceptual knowledge, critical thinking abilities, and students' active participation in the learning process, the deep learning approach is thought to be pertinent in addressing the issues of 21st century education (Baharuddin, 2025).

In the context of education, deep learning is a method of learning that emphasizes thorough conceptual comprehension, in-depth information processing, and the application of knowledge in novel contexts. Deep learning enables students to actively create meaning, integrate new material with past experiences, and reflect on their learning process and results, in contrast to surface learning, which places an emphasis on memorization or repeating of information without thorough comprehension (Hitzler *et al.*, 2025).

The term "deep learning" is an educational approach that emphasizes a thorough comprehension of concepts, active student participation in the learning process, and the capacity to apply and transfer information to novel circumstances and daily life. The phrase was initially used in research on student learning strategies that distinguish between deep learning and superficial learning (Haq & Prasetiyo, 2025).

Deep learning is directly linked to the development of higher-order thinking abilities in 21st-century learning, including analysis, synthesis, evaluation, and flexibility. For young people to acquire critical abilities including creativity, communication, teamwork, and computational thinking, deep learning is required (Wu, 2025).

In addition to emphasizing subject-matter mastery, deep learning fosters the growth of higher-order cognitive abilities including analysis, synthesis, assessment, and reflection (Zhang, 2020). The objectives of 21st-century education, which place a high priority on the development of the 4C competencies critical thinking, creativity, cooperation, and communication are thus well aligned with deep learning. Students' cognitive outcomes were still comparatively low, according to observations made at SD 48/1 Penerokan. Only eight of the 28 pupils completed their coursework.

Students' cognitive learning outcomes are still relatively low, according to preliminary data at SD 48/1 Penerokan. The average score was 56.60, with the highest score reaching 85 and the lowest score 35. Additionally, only a small percentage of students met the minimum learning mastery criteria, indicating that students' cognitive abilities, particularly in understanding concepts and higher-order thinking, need to be improved. As a result, an innovative learning approach, like deep learning, is needed to improve students' cognitive development. According to Penerokan, students' cognitive learning outcomes are still comparatively low. The maximum score was 85, while the lowest score was 35. The average score was 56.60. Furthermore, only few pupils met the minimal requirements for learning mastery. This condition implies that students' cognitive skills need to be strengthened, especially in conceptual understanding and higher-order thinking. Therefore, to improve students' cognitive development, an innovative learning strategy like deep learning is needed.

This implies that the majority of students still struggle to completely understand the course material. This circumstance emphasizes the necessity of a teaching approach that maximizes students' cognitive learning results. As demonstrated by science instruction at Pandanaran Plupuh Junior High School, prior research has demonstrated that the application of a deep learning strategy can successfully enhance students' cognitive capacities (Nurdiana & Pradana, 2025). The Independent Curriculum's use of joyful learning, which fosters an enjoyable and dynamic learning environment, is one of the benefits of deep learning (Hidayat *et al.*, 2025).

Deep learning's benefit is that it can learn from data on its own without requiring manually defined features. Deep learning is useful in many different disciplines since it can generalize a variety of data patterns. Deep learning usually outperforms conventional machine learning techniques in tasks like image identification or natural language processing. Deep learning eliminates the need to manually define features because the network learns to identify them on its own (Tarumingkeng, 2024). In order to solve these issues, a deep learning strategy is used in the classroom to improve students' cognitive capacities by encouraging critical thinking, active participation, and meaningful comprehension of the subject matter.

In addition, the implementation of deep learning in elementary education is expected to create a learning environment that encourages students to become more independent, active, and reflective learners. Through deep learning, students are not only trained to memorize information but also encouraged to analyze problems, connect concepts with real-life situations, and develop logical reasoning skills. This learning approach provides opportunities for students to explore knowledge through discussion, collaboration, and inquiry-based activities, so that learning becomes more meaningful and engaging. Consequently, students are able to develop stronger cognitive abilities that support their academic achievement and prepare them to face the challenges of the modern era.

Furthermore, deep learning also supports the role of teachers as facilitators who guide students in constructing their own understanding. Teachers are required to design learning activities that stimulate curiosity, encourage critical questioning, and provide authentic learning experiences. In this way, students can participate actively in the learning process and gain deeper conceptual understanding. The application of deep learning is therefore considered capable of improving not only cognitive learning outcomes but also students' motivation, confidence, and problem-solving abilities in various learning contexts.

Moreover, the integration of deep learning into classroom instruction can contribute to the achievement of educational goals in the 21st century by fostering lifelong learning skills. Students who experience meaningful and reflective learning processes tend to develop better adaptability, communication skills, and collaborative attitudes. These competencies are essential for students to compete and survive in an increasingly complex and technology-driven world. Therefore, the use of deep learning strategies in elementary schools is highly relevant and necessary to improve the quality of education and optimize students' cognitive development.

METHODS

Constructivism (Piaget and Vygotsky) and Ausubel's Meaningful Learning Theory, which emphasize that knowledge is actively constructed by connecting prior experiences with new information to achieve long-term retention, are the foundations of this pedagogical mechanism. The experimental group received an intervention through a deep learning approach operationalized via inquiry-based and contextual learning, while the control group followed traditional teacher-centered instruction. This study uses a quantitative approach with a quasi-experimental post-test only control group design. Students at SD 48/1 Penerokan make up the research population, and samples are chosen at random to provide each participant an equal chance of being chosen. While the control group got conventional teacher-centered training, the experimental group received an intervention using a deep learning method operationalized through inquiry-based and contextual learning. Constructivism (Piaget and Vygotsky) and Ausubel's Meaningful Learning Theory, which emphasize that knowledge is actively created by linking past experiences with new information to enable long-term retention, are the foundations of this instructional technique.

The goal of the deep learning intervention was to enhance higher-order thinking abilities (HOTS), which include evaluation, synthesis, and analysis as defined by Bloom's Taxonomy. This method turns students from passive recipients into active learners who can solve problems methodically, which is in line with 21st-century competency frameworks (4C: Critical Thinking, Creativity, Collaboration, and Communication).

An independent samples t-test with a 5% significance level (α = 0.05) was used to test the research hypotheses, determining whether the deep learning approach had a significant impact (H_a) or not (H_0) on students' cognitive capacities. Prior to implementation, the research instrument underwent validity and reliability testing to ensure high-quality data; ethical procedures were maintained through subject consent during the sampling process; and data analysis followed strict statistical procedures, including normality (Kolmogorov-Smirnov) and homogeneity (Levene's test). To guarantee high-quality data, the research instrument was tested for validity and reliability before being put into use. Subject consent ensured that ethical protocols were upheld during the sample procedure. Strict statistical methods were followed in the data analysis, including homogeneity (Levene's test) and normality (Kolmogorov-Smirnov) precondition tests to meet parametric assumptions. Lastly, the research hypotheses were tested using an independent samples t-test with a 5% significance threshold (α = 0.05) to ascertain whether the deep learning strategy significantly affected students' cognitive abilities (H_a) or not (H_0).

RESULTS

The findings of this study show that using a deep learning approach significantly improves students' cognitive abilities. This result shows a significant educational influence on students' knowledge construction and processing in addition to a statistical difference. The core features of deep learning, which prioritize meaningful learning, active engagement, and the development of higher-order thinking abilities like analysis, evaluation, and problem-solving, can account for this improvement (Fullan, 2018). With this method, students are positioned as active participants who construct their own understanding through inquiry-based and contextual learning experiences rather than as passive recipients of knowledge.

Students in the experimental class performed better than those in the control class, according to the empirical results. This implies that the deep learning strategy is more effective in promoting cognitive development than traditional methods. The significant difference between the two groups supports the claim that instructional strategies are critical in determining students' cognitive outcomes.

Additionally, the increase in students' capacity to recognize issues and methodically develop solutions suggests that deep learning fosters the growth of structured thinking processes. This is consistent with constructivist learning theory, which holds that knowledge is actively constructed by learners through interactions with their surroundings and educational activities.

Students' deeper understanding was further enhanced by the use of structured and contextual questions aligned with the learning material. These tasks help students connect prior knowledge with new information, thereby promoting meaningful learning and long-term retention. This finding is consistent with previous studies, which show that deep learning approaches can improve cognitive abilities as well as critical thinking and problem-solving skills across various educational contexts.

The results of the prerequisite tests indicate that the data met the assumptions required for further analysis. The homogeneity test using Levene's test yielded a significance value of 0.890 (> 0.05), indicating that the data were homogeneous. Furthermore, the normality test using the Kolmogorov-Smirnov test showed significance values of 0.066 for the experimental class and 0.065 for the control class (both > 0.05), indicating that the data were normally distributed.

Table 1. Normality and Homogeneity Test Results

Class	Normality	Homogeneity
Control	0.890	0.065
Experiment		0.066

Because the deep learning approach actively involves students in creating their own understanding, the experimental class received a higher mean score (74.80) than the control class (67.20). Students are encouraged to think critically, evaluate data, and make connections between new and existing ideas through inquiry-based and contextual learning. In contrast to the traditional approach, where pupils are typically more passive, this results in deeper comprehension and higher retention.

Table 2. Descriptive Statistics

Class	Average Score	Standard Deviation	Maximum Score	Minimum Score
Experimen	74.80	12,623	100	50
Control	67.20	of 12,423	90	40

The Independent Samples t-test for hypothesis testing revealed a significant value of 0.037 (< 0.05), meaning that H_0 is rejected and H_a is accepted. This indicates that pupils who were taught utilizing the deep learning approach differed statistically significantly from those who were not. Therefore, the researcher comes to the conclusion that the Impact of the Deep Learning Approach on Students' Cognitive Abilities at SD 48/1 Penerokan is significant.

Table 3. Hypothesis

Independent Samples Test	
t	Sig. (2-tailed)
-2.146	.037

The experimental class's mean score is greater than the control class's, as indicated by the negative t-value (-2.146). Thus, it can be said that the deep learning method significantly improves pupils' cognitive capacities. Additionally, it has been demonstrated that the deep learning approach enhances students' cognitive capacities, leading to better conceptual comprehension. The findings of this study are corroborated by a systematic review that claims the deep learning approach can successfully raise the standard of basic education (Fullan, 2018).

Deep learning is thought to be effective in improving students' cognitive outcomes in the learning process because it fosters active engagement, critical thinking, and meaningful learning experiences, all of which contribute to better understanding and retention of knowledge. Additionally, deep learning creates interactive and student-centered learning environments that support both cognitive and social development. Previous studies have demonstrated that the implementation of a deep learning approach can improve students' cognitive abilities across different educational levels. This method encourages critical thinking, active participation, and meaningful learning opportunities, all of which improve comprehension and memory. Furthermore, deep learning fosters student-centered, interactive learning settings that promote social and cognitive growth. As a result, the deep learning method is thought to be successful in improving students' cognitive learning outcomes.

The findings indicate that deep learning contributes positively to students' cognitive development, motivation, engagement, and 21st-century skills, particularly critical thinking, collaboration, and creativity. However, its implementation in Indonesia faces several obstacles, including limited teacher competence, inadequate assessment systems, insufficient contextual learning materials, and unequal technological infrastructure (Wr *et al.*, 2026).

This study examines how using Deep Learning technology might enhance students' cognitive skills in Yogyakarta High Schools' Independent Curriculum. With a 34.2% contribution, the findings demonstrate a favorable correlation between students' cognitive development and the use of deep learning. The regression equation Y = 33.136 + 1.241X demonstrates that pupils' cognitive capacities increase with the amount of Deep Learning applied. Despite its effectiveness, issues with infrastructure, teacher preparedness, and student preparedness still need to be resolved. This technology can be optimized to facilitate more interactive, adaptive, and data analysis-based learning with the help of the government and educational institutions, boosting educational efficacy and accomplishing the objectives of the Independent Curriculum (Suardin *et al.*, 2025).

DISCUSSION

The findings of this study demonstrate that the implementation of a deep learning approach has a significant positive effect on students' cognitive abilities. This improvement is not only reflected in statistical differences but also in meaningful educational impacts, particularly in how students construct, process, and apply knowledge. The deep learning approach emphasizes meaningful learning, active engagement, and the development of higher-order thinking skills such as analysis, evaluation, and problem-solving. These characteristics position students as active learners who construct their own understanding through inquiry-based and contextual learning, rather than merely receiving information passively (Le & Nguyen, 2024).

Empirical results show that students in the experimental class outperformed those in the control class, indicating that the deep learning approach is more effective than conventional teaching methods in promoting cognitive development (Chen, 2024). The statistically significant difference between the two groups confirms that instructional strategies play a crucial role in shaping students' cognitive outcomes. Furthermore, the improvement in students' ability to identify problems and develop structured solutions suggests that deep learning fosters systematic and analytical thinking processes, which are essential components of cognitive development (Vidergor, 2022).

These findings are supported by constructivist learning theory, which emphasizes that knowledge is actively constructed through interaction with the environment and learning experiences. The use of structured and contextual questions in the learning process further strengthens students' understanding by connecting prior knowledge with new information. This promotes meaningful learning and enhances long-term retention, which are key indicators of successful cognitive development.

The results of prerequisite tests confirm that the data met the assumptions required for parametric analysis. The homogeneity test indicated that the data were evenly distributed, while the normality test confirmed that both experimental and control groups followed a normal distribution. This strengthens the validity of the statistical analysis conducted in this study. Additionally, descriptive statistics revealed that the experimental group achieved a higher mean score compared to the control group, further supporting the effectiveness of the deep learning approach.

The hypothesis testing using the independent samples t-test showed a significant difference between the two groups, with a significance value of 0.037 (< 0.05). This result indicates that the application of the deep learning approach has a statistically significant impact on students' cognitive abilities. The negative t-value further confirms that the experimental group performed better than the control group.

These findings are consistent with previous studies that highlight the effectiveness of deep learning approaches in improving cognitive abilities, critical thinking, and problem-solving skills across different educational levels. Research conducted in various contexts has shown that deep learning contributes not only to academic achievement but also to the development of essential 21st-century skills, including collaboration, creativity, and engagement. In addition, studies have reported positive correlations between the use of deep learning and students' cognitive development, reinforcing the argument that this approach is highly beneficial in modern education.

However, despite its effectiveness, the implementation of deep learning in educational settings still faces several challenges. These include limited teacher competence in applying innovative teaching strategies, inadequate assessment systems, lack of contextual learning materials, and unequal access to technological infrastructure. These barriers need to be addressed to maximize the potential of deep learning in improving educational outcomes.

Overall, this study confirms that the deep learning approach is an effective strategy for enhancing students' cognitive abilities. It promotes meaningful learning, supports the development of higher-order thinking skills, and encourages active student participation. Nevertheless, successful implementation requires strong support from educational institutions, teacher readiness, and adequate infrastructure. Future research is recommended to explore long-term impacts and to investigate strategies for overcoming implementation challenges in different educational contexts.

CONCLUSIONS

The results of the study at SD 48/1 Penerokan show that using a deep learning approach significantly affects students' cognitive capacities, as shown by the null hypothesis being rejected with a significance value of 0.037. Beyond statistical findings, this study creates a crucial novelty by showcasing deep learning's efficacy in the particular setting of the Independent Curriculum (Kurikulum Merdeka) framework and the Indonesian elementary education system. The study demonstrates a successful contextualized pedagogical adaptation in which high-level concepts are translated into localized classroom dynamics that shift from passive, teacher-centered rote learning toward active knowledge construction. This approach specifically improved cognitive indicators like analytical thinking, systematic problem-solving, and the capacity to apply knowledge to everyday situations. Deep learning is a transformative and effective alternative, but attaining the best outcomes necessitates strong teacher preparation, careful lesson planning that is in line with local needs, and a supportive, happy learning environment. In particular, this method enhanced cognitive indicators including analytical thinking, methodical problem-solving, and the capacity to apply knowledge to real-world scenarios. Although deep learning is a revolutionary and successful substitute, attaining the best outcomes necessitates strong teacher preparation, careful lesson planning that is in line with regional needs, and a supportive, happy learning environment.

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