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Innovative strategies in utilizing deep learning implementation in elementary schools

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ABSTRACT

This study aims to analyze teachers' innovative strategies in the implementation of deep learning-based learning in elementary schools. The background of the research departs from the challenges of 21st century education that demand critical thinking, collaboration, and creativity skills, while learning practices in elementary schools still tend to be conventional and passive. Previous studies have shown the effectiveness of deep learning in improving students' literacy, numeracy, and reflective skills, but aspects of teachers' strategies in the context of elementary schools are still rarely studied. This research uses a qualitative approach with a case study design at SDN Cicalengka 08 and SDN Pelita Bandung Regency. Data was collected through interviews, observations, and documentation, then analyzed with the interactive model Miles, Huberman, and Saldana and tested for validity using triangulation of sources and methods. The results of the study showed that teachers applied innovative strategies through the PDCA (Plan-Do-Check-Act) cycle. Planning is carried out by analyzing student needs and adjusting the curriculum, implementation using active methods such as group discussions, educational games, and interactive media, evaluation includes analytical tests, observations, and projects, while follow-up is in the form of providing feedback and reflection on strategies. The main obstacles include limited facilities, variations in student readiness, time constraints, and suboptimal parental support. The conclusion of this study confirms that innovative strategies based on deep learning are able to increase students' motivation, engagement, and 21st century skills. The novelty of the research lies in the integration of Piaget's theory of cognitive development with the PDCA framework, which produces contextual and participatory strategy models according to the characteristics of elementary school students.

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Introduction

In a global context, the development of artificial intelligence (AI) technology and especially deep learning has brought significant changes in the world of basic education. Deep learning, as a key component of AI, enables more in-depth data analysis and personalization of the learning experience for students through interactive media that can improve their engagement and learning outcomes (Cao and Sun 2024; Rong, Yao, and Bai 2024). The application of deep learning in education supports the analysis of student performance

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patterns and creates learning paths that suit individual needs, as shown by research on educational data analytics (Rong et al. 2024; Yan et al. 2023). By using these techniques, teaching can be more responsive to students' development, facilitate deeper learning, and improve their writing skills and cognitive abilities (Bal and Öztürk 2025; Li and Zhang 2025). The contribution of platforms developed by large companies also strengthens the effectiveness of the application of this technology in the context of education (Ouahi, Khoulji, and Kerkeb 2024).

Indonesian Law No. 20 of 2003 emphasizes the importance of holistic national education goals, including cognitive, affective, and psychomotor aspects. This shows that education must integrate students' intellectual, emotional, and physical development to form character (Chuntala and Setyaningsih 2020). The importance of learning strategies that are able to develop character, creativity, and critical thinking is very evident in the context of 21st century skills, which include communication, collaboration, creativity, and problem-solving (Alifah and Sukartono 2023; Ismail, Aziz, and Chea 2024; Ramadhanti 2024).

Deep learning aligns with this goal because its approach emphasizes a deep understanding of the learning process and the development of 21st-century skills needed to meet global challenges. By integrating technology in learning, students are able to offer innovative solutions and think critically in complex situations (Dahri et al. 2023; Herfina 2022). This integration supports education that is responsive and adaptive to the needs of the times, as well as producing a generation that is ready to contribute to society (Djoeaeriah and Iskandar 2024).

In education, deep learning is defined as a learning process that focuses on deep understanding, not just memorization. In this paradigm, teachers play the role of facilitators who create an active, reflective, and collaborative learning environment (Thien, Leong, and Por 2021; Weng, Chen, and Ai 2022). Collaboration and reflection allow students not only to know information but also to understand and apply it in a variety of contexts (Pires et al. 2020). The goal of this approach is to encourage students to internalize knowledge and develop critical thinking and problem-solving skills (Sun et al. 2022). Along with the development of technology and innovative pedagogy, such as reverse and design-based learning models, the learning process has become increasingly interactive and adaptive to the needs of students (Hava 2021).

The implementation of deep learning in education is greatly influenced by the learning strategies applied by teachers. Teachers play the role of facilitators in creating active and contextual learning experiences, which encourage effective student engagement (Wulan and Syaleh 2023). Innovative strategies include active learning and the use of contextual media that allow students to learn collaboratively and think critically (Nduati et al. 2021; Phuong et al. 2020). However, the main challenge in primary education is that the learning process is still concrete, instructional, and one-way, thus hindering the application of deep understanding (Baticulon et al. 2021). To address this, approaches such as problem-based and collaborative learning are needed that can enhance student interaction and engagement, so that they achieve a deeper understanding (Hapsari et al. 2023; Liu, Seemuang, and Kaenampornpan 2024).

The empirical conditions at SDN Cicalengka 08 and SDN Pelita show that the implementation of deep learning is not optimal. Learning is still conventional, students tend to be passive, and have not been encouraged to think critically. This is a challenge for teachers in creating meaningful learning at the elementary school level. According to Jean Piaget's theory of cognitive development, elementary school children are at a concrete operational stage, where they need hands-on experience to understand concepts (Khairunnisa et al. 2025; Wardani 2022). At this stage, students are able to think logically about concrete objects, but

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have difficulty understanding abstract concepts (2023 الحفيظ). Therefore, teachers need to implement contextual strategies and real activities that allow students to interact directly with the material, so that learning is more meaningful and relevant (Lorca 2023; Sugianto, Darmayanti, and Vidyastuti 2022).

Some innovative strategies that can be used include the use of manipulative use, project-based learning, and interactive media (Zikrulloh et al. 2025). Activities such as practical experiments and educational games help students better understand scientific and mathematical principles, while encouraging exploration and reflection (Obasi and Obi 2025). By adapting learning methods that are appropriate to the stages of students' cognitive development, it is hoped that the teaching and learning process will be more effective, meaningful, and fun in elementary school.

Previous Research, Gap, and Novelty

A number of previous studies have shown the important role of deep learning and innovative learning strategies in improving the quality of basic education. Ferdiansyah et al. (2025) found that the application of deep learning was able to improve the critical thinking skills of elementary school students. Furthermore, Nashrulloh et al. (2023) emphasized that teachers' innovative strategies contribute to increasing student engagement and learning motivation. Nafi'ah and Faruq (2025) also shows that the integration of the concept of mindful, meaningful, joyful learning has proven to be effective in improving the quality of learning, even though it still faces obstacles to teacher and infrastructure limitations. Meanwhile, Utami, Nur, and Liyong (2025) revealed that deep learning supports strengthening collaboration and critical thinking skills when combined with learning technology. In line with these findings, other research by Royani, Ahda, and Silalahi (2024) also affirmed the contribution of deep learning in various educational contexts, both related to improving literacy, numeracy, and the development of students' reflective skills.

However, previous studies have shown a number of limitations. Most of the research focuses on the effectiveness of deep learning on learning outcomes, such as critical thinking, creativity, literacy, and numeracy, while aspects of teachers' innovative strategies in the implementation of deep learning are still rarely studied in depth. In addition, contextual research in elementary schools that face real challenges, such as conventional learning strategies, teacher readiness, and classroom dynamics, is still very limited. This condition raises the need for a study that focuses more on how teachers develop and implement innovative strategies in the context of deep learning-based learning.

Based on this, this research offers novelty by focusing on the identification and analysis of teachers' innovative strategies in the implementation of deep learning in elementary schools. In addition, this study integrates Piaget's theory of cognitive development with the PDCA (Plan-Do-Check-Act) framework to understand the process of planning, implementing, evaluating, and improving learning strategies. With this approach, it is hoped that the research can contribute in the form of innovative learning strategy models that are contextual, participatory, and in accordance with the developmental characteristics of elementary school students. This research aims to find and analyze innovative strategies applied by teachers in supporting the implementation of deep learning in elementary schools. In particular, the objectives of this research include three things. First, identify various strategies used by teachers in developing deep learning-based learning at SDN Cicalengka 08 and SDN Pelita. Second, analyze the challenges faced by teachers in designing and implementing innovative learning strategies based on deep learning. Third, formulate innovative strategy models that are in accordance with the characteristics of the cognitive development of elementary school

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students, so as to be able to create a more meaningful, contextual, and supportive learning experience for 21st century skills.

Method

This research uses a qualitative approach with a case study design, because it aims to explore in depth the innovative strategies of teachers in implementing deep learning-based learning in elementary schools. The qualitative approach was chosen because it was able to provide a comprehensive understanding of real experiences, perceptions, and practices in the field. According to Sugiyono (2018), qualitative research is based on the philosophy of postpositivism, used to examine the condition of natural objects, where researchers act as key instruments. This approach is also in line with Creswell (2018) who explains that qualitative research is used to explore and understand the meaning derived from the experiences of individuals or groups in a particular social context.

This research was carried out at SDN Cicalengka 08 and SDN Pelita Bandung Regency. The two schools were chosen because they showed efforts to implement a deep learning approach, although in practice they still faced obstacles related to learning strategies, teacher readiness, and classroom dynamics. The subjects of the study include classroom teachers, principals, and students. Teachers and principals are chosen because they play a direct role in the planning, implementation, and evaluation of learning, while students are engaged to gain an authentic perspective on their learning experiences.

Research data was collected through in-depth interviews, observations, and documentation studies. Interviews were used to explore the views, strategies, and experiences of teachers and principals in the application of deep learning (Moleong, 2019). Observations were carried out to obtain a real picture of the learning process in the classroom, including teacher-student interaction, media use, and forms of student involvement (Anggito & Setiawan, 2018). The documentation study is aimed at examining related documents, such as Learning Implementation Plans (RPP), learning outcome records, and relevant school policies.

Data analysis used the interactive model of Miles, Huberman, and Saldana (2014), which included three main stages. First, data reduction, which is selecting, simplifying, and focusing data on important aspects according to the research objectives. Second, the presentation of data in the form of a descriptive narrative so that the findings can be understood systematically. Third, drawing conclusions and verifying through the interpretation of data meaning, pattern search, and comparison between data sources.

To maintain the validity of the findings, this study used a triangulation technique. Source triangulation is carried out by comparing information obtained from teachers, principals, and students, while triangulation methods are carried out by combining the results of interviews, observations, and documentation (Patton, 2015). In this way, the validity of the data can be accounted for so that the results of the research truly reflect the empirical conditions in the field.

Result

The results of this research were obtained through in-depth interviews, classroom observations, and documentation studies using data triangulation at SDN Cicalengka 08 and SDN Pelita. Based on the PDCA (Plan-Do-Check-Action) framework developed by W. Edwards Deming, research findings can be explained through five main aspects, namely planning, implementation, evaluation, follow-up, and implementation constraints.

Learning Strategy Planning

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Teachers start the learning process by analyzing student needs. This analysis was carried out through reviewing the results of previous evaluations, simple questions and answers, and observations of students' learning styles. One teacher stated: *"We usually look at the results of the test and ask the students directly to find out who already understands and who still needs guidance."* In addition, school conditions are also important considerations, including infrastructure, number of students, and school policies. All of the results of this analysis are outlined in the lesson plan and teaching modules that are in line with the Independent Curriculum. Teachers emphasized the importance of learning outcomes, differentiated learning, and the development of students' creativity and critical thinking skills.

Implementation of Innovative Strategies

The implementation of learning took place according to plan, but teachers remained flexible in adjusting to class conditions. Observations in the classroom show that teachers present an interesting learning atmosphere through educational games, interactive quizzes, short videos, and the use of visual aids. Teachers also often use stories or dramatizations to make learning more lively. Small group discussions are the dominant strategy, where students actively discuss and present ideas. One student said: *"If we study with a group discussion it is more fun, we can ask each other questions and find answers together."* This strategy helps students develop critical thinking, cooperation, and communication skills.

Learning Evaluation

Evaluation is carried out with a combination of written tests, observations, and project assessments. Written tests are designed not only to measure memorization, but also analytical ability. The teacher said: *"The questions I create usually ask students to explain the reason for their answers, so that they get used to thinking more deeply."* In addition, student involvement observations are carried out regularly, recording participation, attitudes, and cooperation in group activities. Project assessments are an important instrument because they provide opportunities for students to express creativity. Some students affirm that they prefer project assessments, such as creating posters or models, because they can work together with friends while also showing real work.

Follow-up and Strategy Improvement

After the evaluation, the teacher followed up in the form of giving feedback, both individually and in groups. This feedback aims to make students understand the strengths and weaknesses of learning. Teachers also reflect on the effectiveness of learning strategies. One teacher stated: *"Every time I finish learning, I always review whether my method is suitable for the student's condition or still needs to be improved."* In addition, the school supports follow-up by organizing regular training and workshops. The program helps teachers strengthen their professional capacity in implementing innovative strategies. Thus, deep learning-based learning strategies can run continuously and consistently.

Implementation Constraints

Although innovative strategies have been designed and implemented, the study found some obstacles on the ground.

- First, the limitation of infrastructure is still a challenge. One teacher stated: *"Sometimes it is difficult if the internet network in school is unstable, so the media that has been prepared cannot be used."*
- Second, the variation in students' readiness in understanding the material makes teachers have to work extra. Another teacher said: *"There are children who catch it very quickly, but*

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there are also those who have to be guided many times. That made me have to adjust my strategy halfway."

- Third, time constraints due to tight schedules often make project-based activities not optimal. One student complained: *"If the time is short, we won't have time to complete the project to the fullest."*
- Fourth, some teachers find it difficult to design problems that really encourage high-level thinking. In addition, support from parents is not fully optimal, because there are still more emphasis on value outcomes than the learning process.

Discussion

Planning and Implementation of Innovative Strategies

The findings show that teachers at SDN Cicalengka 08 and SDN Pelita carried out systematic lesson planning, taking into account not only the formal curriculum but also students' actual conditions. Teachers analyzed students' needs, learning motivation, and available resources before compiling lesson plans. This reflects the principle of differentiated learning emphasized in the Independent Curriculum. These findings are consistent with Nashrulloh et al. (2023), who highlighted that teachers' innovative strategies enhance student engagement and motivation. In practice, teachers integrated models such as Problem-Based Learning (PBL), collaborative learning, and simple educational games. These strategies proved effective in increasing student participation while facilitating deep understanding rather than rote memorization. This is in line with Ferdiansyah et al. (2025), who found that deep learning improves elementary students' critical thinking skills.

Implementation of Deep Learning-Based Teaching

The teaching process demonstrated teachers' flexibility in adapting strategies to classroom conditions. For instance, when digital tools were limited, teachers replaced them with simpler media without diminishing the learning essence. Observations revealed that lessons were dynamic, involving small group discussions, interactive quizzes, and short videos. These strategies not only enhanced students' intrinsic motivation but also strengthened communication and collaboration skills. This supports the findings of Utami, Nur, and Liyong (2025), who argued that deep learning effectively fosters collaboration and critical thinking, especially when combined with technology or interactive approaches. Thus, this study reaffirms the central role of teachers in adapting methods to remain relevant to classroom realities.

Learning Evaluation

Evaluation at both schools was not limited to written tests but also included observations of student participation and project-based assessments. Teachers encouraged students not only to provide answers but also to explain their reasoning, thereby fostering critical thinking habits. This aligns with Royani, Ahda, and Silalahi (2024), who found that deep learning contributes to strengthening literacy, numeracy, and reflective skills. Moreover, project-based assessments, such as poster creation or simple reports, were perceived by students as more enjoyable, as they allowed for collaboration and creativity. This finding supports Nafi'ah and Faruq (2025), who emphasized that mindful, meaningful, and joyful learning enhances educational quality despite challenges related to resources and teacher readiness.

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Follow-Up and Teacher Reflection

Follow-up after evaluation formed an integral part of the PDCA cycle. Teachers provided feedback both individually and in groups, while also reviewing the effectiveness of their strategies. This reflective practice enabled continuous improvement, including adjusting methods or proposing further training. Schools supported this process through workshops and professional development programs, which helped minimize disparities in teachers' capacity to apply innovative strategies. These findings reinforce earlier studies that highlighted teacher creativity and preparedness as crucial factors in the success of deep learning (Nashrulloh et al., 2023; Utami et al., 2025).

Constraints in Implementing Deep Learning

Despite these efforts, several challenges emerged in practice. First, limited technological infrastructure often hindered the use of digital media. Second, variations in student readiness required teachers to make continuous adjustments. Third, time constraints prevented optimal implementation of project-based activities. Fourth, administrative burdens reduced teachers' focus on planning and evaluating instruction. These findings resonate with Nafi'ah and Faruq (2025), who identified teacher limitations and inadequate infrastructure as persistent challenges in implementing innovative learning. Additionally, the lack of optimal parental support, coupled with a stronger emphasis on grades over learning processes, added to the difficulties faced by teachers.

Research Gap and Novelty

Integrating these findings with prior studies highlights an existing research gap. Most previous works have focused on the effectiveness of deep learning in improving outcomes such as critical thinking, creativity, literacy, and numeracy (Ferdiansyah et al., 2025; Royani et al., 2024). However, the dimension of teachers' innovative strategies in implementing deep learning particularly in elementary school contexts with limited resources remains underexplored. This study therefore offers novelty by centering on innovative teacher strategies designed through the PDCA framework and grounded in Piaget's theory of cognitive development. The findings not only reaffirm the importance of deep learning but also contribute by proposing a contextual, participatory, and developmentally appropriate strategy model for elementary students.

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Conclusion

This research proves that the implementation of innovative strategies based on deep learning at SDN Cicalengka 08 and SDN Pelita has been carried out systematically through the PDCA cycle. Teachers are able to plan differentiated learning, implement creative methods such as PBL and group discussions, and conduct authentic evaluations and reflective follow-ups. This strategy has been shown to increase students' motivation, engagement, and 21st century skills. However, limited facilities, variations in teacher readiness, administrative burden, and lack of parental support are still major obstacles. Therefore, the success of deep learning in elementary schools demands not only teacher innovation, but also institutional support, infrastructure, and collaboration with families and communities.

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