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The Role of Deep Learning in Elementary Education: Pedagogical Insights from a Literature Study

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Abstract

This study aims to explore the concept and implementation of deep learning at the elementary school level through a literature-based approach grounded in contemporary pedagogical theories and practices. The research employs a descriptive qualitative methodology, drawing on a systematic review of literature from scientific journals, academic books, policy reports, and both national and international research studies. The analysis was conducted thematically by categorizing findings into conceptual foundations, implementation models, mental actions, the role of teachers, and supporting pedagogical principles such as active engagement, differentiation, and positive reinforcement. The results of the review indicate that deep learning emphasizes students' cognitive engagement through higher-order mental activities such as analysis, synthesis, evaluation, and critical reflection on information. This approach is rooted in constructivist theories (Piaget, Vygotsky), the theory of meaningful learning (Ausubel), and the concept of mindful education (Langer), which together form a robust theoretical basis for facilitating meaningful and contextual learning. Teachers play a pivotal role as facilitators in creating inclusive and dialogic learning environments that enable students to actively explore and engage in social collaboration to construct deep understanding. In conclusion, the integration of deep learning into elementary education has the potential to enhance the quality of teaching and learning processes by fostering critical and creative thinking patterns, while also preparing learners to be adaptive and reflective. These findings provide a conceptual and practical foundation for developing future pedagogical strategies in response to the challenges of 21st-century education.

Keywords: Deep learning, Elementary education, Pedagogical insight.

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1. Introduction

Primary education plays a fundamental role in shaping the intellectual, social, emotional, and moral development of young learners (Akbar et al., 2023). At this stage, children begin to form the cognitive foundations necessary for understanding various academic concepts while also developing the skills to participate in structured learning environments. For this reason, instructional strategies at the elementary level should aim not only at academic mastery but also at fostering character development and essential thinking competencies to meet the challenges of a rapidly changing world (O'Reilly et al., 2022).

As educational systems continue to evolve in the twenty-first century, there is increasing emphasis on approaches that promote deeper levels of cognitive engagement (Susandi et al., 2022). Among these, deep learning has emerged as a pedagogical strategy that encourages students to construct meaningful knowledge, apply it in diverse contexts, and engage in reflective thinking. Rather than promoting memorization, this approach emphasizes analysis, synthesis, and understanding that is both contextual and long-term (Setiyowati and Panggayuh, 2019).

Unlike surface learning, which often relies on rote memorization without comprehension, deep learning requires students to participate actively and critically in their own learning processes (Mu'ti, 2025). In the context of primary education, it is important to consider children's

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cognitive development. According to Piaget, children in this stage operate within the concrete operational phase, where logical thinking is possible but limited to tangible and observable experiences (Piaget, 1950). Accordingly, teaching practices should emphasize experiential learning, hands-on activities, and real-world applications to support conceptual understanding.

Several pedagogical frameworks have been found effective in supporting deep learning among elementary students. These include project-based learning, inquiry-based learning, and problem-based learning models (Priantari et al., n.d.). Each model emphasizes active involvement, collaboration, and contextual learning. Despite these benefits, researchers have also noted various challenges in implementation, such as insufficient teacher training, curriculum constraints, exam-driven teaching practices, and lack of awareness about how to design meaningful lessons.

In the Indonesian education system, curriculum reforms such as the 2013 Curriculum and the Merdeka Curriculum have introduced a vision for more student-centered and integrative learning experiences. These reforms support the development of well-rounded learners through the Profile of Pancasila Students, which incorporates social, ethical, and intellectual values (Herawati et al., 2023). Nevertheless, gaps in implementation still exist due to unequal access to resources, variability in teacher preparedness, and structural differences across schools and regions.

Globally, researchers emphasize the importance of early integration of deep learning to prepare students with the critical, creative, and collaborative abilities needed for future success (Pradini and Adnyayanti, 2022). However, comprehensive studies that examine how deep learning is applied in elementary education, particularly in developing countries like Indonesia, remain limited. This signals the need for a thorough literature-based inquiry to explore the theoretical underpinnings, practical models, pedagogical strategies, and contextual challenges involved in adopting deep learning at the elementary level.

This paper seeks to address that gap by offering a critical literature review on deep learning in primary education. Drawing upon theoretical discourse and empirical evidence, it aims to generate academic insights and pedagogical implications that can support the advancement of more meaningful and effective teaching practices for young learners.

2. Method

This study employs the library research method, which is a research approach based on the systematic search and analysis of various literature sources relevant to the topic under investigation. This method was selected because the study does not aim to collect primary data through direct observation or interviews, but rather to identify, examine, and synthesize existing theories, empirical findings, and scholarly perspectives related to deep learning in elementary school students. Such an approach enables the researcher to gain a comprehensive understanding of the conceptual and practical developments surrounding the topic, based on previously published academic literature.

The data sources in this study consist of both primary and secondary literature drawn from academic books, national and international journal articles, research reports, conference proceedings, and educational policy documents published by official institutions such as the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, UNESCO, and the OECD. The literature search was conducted using various online databases such as Google Scholar, Scopus, ScienceDirect, and DOAJ, utilizing relevant keywords including: deep learning, elementary education, primary school students, meaningful learning, higher-order thinking skills, and constructivist approaches. However, several classical sources that provide

foundational theoretical contributions were also included to offer a more comprehensive understanding.

The analysis of the literature was carried out using a descriptive-qualitative method with a thematic approach. Each source was examined to identify recurring key themes, such as definitions and characteristics of deep learning, instructional strategies that support it, implementation challenges in elementary schools, and its contribution to the development of higher-order thinking skills. The findings were then synthesized and interconnected within a logically structured conceptual narrative, producing a coherent overview of how deep learning has been developed and applied in the context of primary education. By utilizing the library research method, this article aims to offer a conceptual mapping and critical reflection that enriches academic discourse while also providing practical contributions for teachers, policymakers, and educational researchers in developing more meaningful and relevant learning approaches for primary school-aged children.

3. Results

3.1. The essence of deep learning

Teaching and learning represent the core of the entire educational system, where the teacher plays a central role. Without classroom-based learning processes, the objectives established for each level of education cannot be achieved. This process involves a series of activities carried out by both teachers and students within an interactive and reciprocal relationship. The interaction between teacher and student is critical to the continuity and effectiveness of the learning process.

Learning is a process that results in changes in an individual's behavior as a consequence of experience and practice. Hilgard and Bower (1975) define learning as a change in an individual's response to a particular situation due to repeated exposure to that situation. This behavioral change can be influenced by innate response tendencies, maturation, or temporary states experienced by the individual. Learning is thus a relatively permanent behavioral transformation that occurs due to training or experience, emphasizing the stability and longevity of the acquired knowledge or skills.

Gagné (1985) describes learning as a process that produces changes in an individual in terms of knowledge, skills, and attitudes. Learning occurs when an individual acquires new information that alters how they think, act, and respond to their environment. From a different perspective, Bandura (1977), through his social learning theory, posits that learning takes place through observing and imitating others' behaviors, whereby individuals absorb information from their surroundings and adjust their behaviors accordingly. From these various definitions, it can be concluded that learning is a process that involves changes within an individual—encompassing knowledge, skills, and attitudes—driven by experience or practice.

Swiss cognitive development psychologist Jean Piaget conceptualizes learning as a dynamic activity that arises through the interaction between an individual and their environment. In this process, individuals gradually construct and reconstruct their cognitive structures through two primary mechanisms: assimilation and accommodation. Piaget emphasizes that learning is not a passive reception of information but a constructive activity in which individuals actively build understanding based on their experiences and engagement with the surrounding world.

Lev Vygotsky, a prominent figure in socio-cultural developmental psychology from Russia, asserts that learning is a social activity that occurs through interaction with more experienced individuals, such as teachers, parents, or peers. He stresses that cognitive development is deeply influenced by the social and cultural environment in which a person lives and interacts.

The term deep learning was introduced by Geoffrey Hinton in 2006 (Hinton et al., 2006), a cognitive scientist from the University of Toronto. Deep learning is rooted in artificial neural networks and is often referred to as the next generation of neural networks. This is because properly trained deep neural networks can achieve significant outcomes across various problem domains. As a subset of machine learning, deep learning focuses on utilizing multilayered artificial neural network algorithms to process data in more sophisticated and nuanced ways (Sarker, 2021).

Beyond the realm of technology, the concept of deep learning has been widely adopted in fields such as education, cognitive psychology, didactic studies, and pedagogy. In the context of modern pedagogy, deep learning refers to a learning approach that emphasizes meaningful and in-depth student engagement during the learning process. This approach aims to equip students with the ability to solve complex problems and is inherently oriented toward the development of higher-order thinking skills

In Indonesia, the term deep learning has gained popularity in the field of education since the Minister of Primary and Secondary Education, Abdul Mu'ti, introduced and elaborated on the concept in several public forums. Deep learning refers to a learning approach where students are encouraged to explore knowledge deeply, find meaning, and contextualize or connect lessons with prior knowledge, real-life experiences, and future preparedness (Mu'ti, 2020). According to Mu'ti (2020), the concept of deep learning closely aligns with what is referred to as mindful education. As described by Langer (1993), mindful education is an approach in which learning is carried out with full awareness or mindfulness. It encourages students to be more conscious of the learning process and their environment.

Langer argues that mindfulness in education is not merely about paying attention to the present moment, but also about developing the ability to view problems from multiple perspectives and avoiding rigid or fixed thinking. Mindful education prompts students to adopt a more open and flexible way of thinking. It teaches them not to rush to conclusions or be trapped in established ways of thinking. Instead, they are encouraged to continuously explore possibilities and consider broader perspectives. This approach helps prevent students from falling into automatic patterns of thought, where they absorb information without genuinely understanding the process or reasoning behind what they are learning. Students are guided to reflect more deeply on every concept or piece of information they encounter, leading to a better grasp of the subject matter.

In this context, students are encouraged to cultivate creativity and critical thinking, remain open to new ideas, and adopt innovative approaches to problem-solving, which ultimately enhances their understanding. Mindful education also emphasizes the importance of recognizing broader contexts, enabling students to see how what they learn is relevant to real-world situations and applicable across different scenarios. This increased awareness fosters greater student engagement, resulting in more meaningful and effective learning experiences. Langer posits that this approach not only improves educational outcomes but also makes the learning process more enjoyable, as students feel more motivated and actively involved. Through this heightened awareness of both their learning content and the surrounding world, students are better equipped to develop essential critical and creative thinking skills.

In addition to mindful education, Mu'ti's (2020) interpretation of deep learning also resonates with the concept of meaningful learning, a theory developed by David Ausubel. According to Ausubel, meaningful learning stresses the importance of establishing strong connections between new information and the learner's existing cognitive structure (Martins et al., 2024). This type of learning occurs when new content can be linked to prior knowledge, allowing students to

construct a deeper and more comprehensive understanding. This stands in contrast to rote learning, which relies heavily on memorization and repetition without true comprehension.

In meaningful learning, students are able to associate new concepts with what they already know, which helps embed the new knowledge into a larger framework. This process makes it easier to recall and apply the knowledge in different contexts. Ausubel distinguishes meaningful learning from rote learning. In rote learning, information is memorized without any meaningful connection to existing knowledge, resulting in shallow understanding. Conversely, meaningful learning involves an active process of understanding, where students relate new information to familiar concepts, enabling longer retention and better application across various situations. This requires students to engage in reflective thinking and integrate new knowledge in ways that enrich their comprehension.

In Ausubel's theory, the concept of cognitive structure is central, representing how knowledge is organized within the mind. Existing knowledge within this structure serves as a framework for receiving and understanding new information. When new material can be meaningfully connected to prior knowledge, learning becomes more effective. Ausubel therefore emphasizes that effective learning depends on how well information is organized within the learner's cognitive structure. One method he introduced to support meaningful learning is the use of advance organizers. These are tools that provide students with an overview or related background information before they begin studying new material. The goal is to mentally prepare students and help them connect new information to what they already know. With the use of advance organizers, students are better equipped to understand and remember content, as they can anchor new material to a relevant knowledge framework.

3.2. Mental actions developed in deep learning

Mental actions refer to a series of cognitive processes that occur in an individual's mind as they engage in learning and problem-solving (Harel, 2008). Harel emphasizes that mental actions go beyond mere memorization or mechanical procedural execution; instead, they involve the construction of deep understanding through active mental engagement such as analysis, interpretation, and reflection. In mathematics learning, for example, mental actions include analyzing problems, modeling situations, selecting appropriate problem-solving strategies, evaluating, proving, interpreting, connecting, modeling, generalizing, symbolizing, and so forth (Harel, 2008).

In practice, deep learning facilitated by teachers should be oriented toward higher-order mental actions. Referring to the cognitive taxonomy proposed by Bloom (1956), deep learning aims to develop students' abilities in the domains of analysis, synthesis, and evaluation. In Bloom's taxonomy, these three domains are considered higher levels of thinking that require students to think more deeply and critically. In the analysis phase, students are expected to break down information into smaller components and understand the relationships among them. This enables them to recognize patterns, assumptions, or errors in the provided information, as well as to better understand the structure and organization of the material.

Next, during the synthesis phase, students are encouraged to combine various pieces of information or ideas they have learned to generate something new. This process involves the ability to design or plan something using existing knowledge. In the evaluation phase, students are required to assess the quality or value of information or proposed solutions based on predetermined criteria. Rather than merely organizing or accepting information, they are expected to evaluate and make decisions based on available evidence. These three stages are interconnected and form the framework of critical thinking needed to solve complex problems.

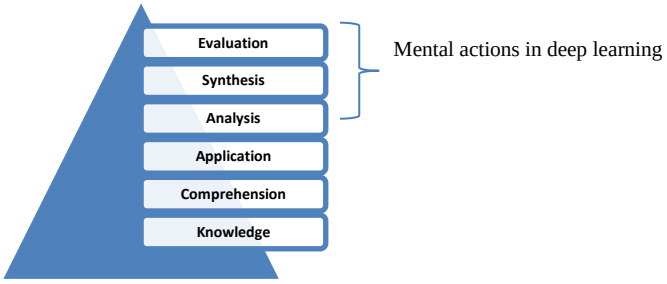

Figure 1: The mental actions developed in deep learning based on Bloom's Taxonomy

In addition to Bloom's Taxonomy, which has long served as a reference in instructional goal planning, Webb's Depth of Knowledge (DOK) can also be utilized as an alternative conceptual framework that supports the implementation of deep learning (Gun and Bosse, 2025). The DOK framework, developed by Norman L. Webb, not only emphasizes the types of cognitive activities undertaken by students but more importantly highlights the level of complexity and depth of thinking involved in completing a task or addressing a problem. In this context, teachers can use DOK to design learning experiences that encourage students not merely to memorize or comprehend superficially, but to apply knowledge strategically (DOK 3) and even to integrate and critically evaluate information in complex situations (DOK 4). This process aligns with the core principles of deep learning, which demand high cognitive engagement, authentic problem-solving, and the transfer of knowledge across various contexts. Therefore, the application of Webb's DOK in instructional practice plays a crucial role in shaping meaningful, reflective learning processes that have a lasting impact on the development of higher-order thinking skills.

Table 1. The Four Levels of Webb's Depth of Knowledge (DOK) Thinking Taxonomy

Level	Level Name	General Description	Example Activities
DOK 1	Recall and Reproduction	Refers to the ability to recall or reproduce basic facts, information, or procedures. No complex reasoning is required	Stating legal definitions, memorizing articles of law, performing simple calculations
DOK 2	Skills and Concepts	Involves using skills and concepts in relatively familiar contexts. Requires conceptual understanding	Explaining cause and effect, interpreting simple graphs, classifying information
DOK 3	Strategic Thinking	Involves reasoning, evaluation, and decision-making. Requires justification and more complex cognitive strategies	Analyzing case studies, comparing two legal theories, constructing arguments with evidence
DOK 4	Extended Thinking	Involves synthesis, in-depth evaluation, and solving complex problems, often over time and using multiple data sources	Designing research projects, conducting court simulations, evaluating public policies

These mental actions are central to the deep learning approach, which seeks not merely to memorize information but to develop deeper understanding that can be applied in broader and novel contexts. In deep learning, students are encouraged not only to recall facts or procedures but also to comprehend, analyze, and connect concepts in more complex ways. This approach emphasizes full awareness of the learning process and aims to engage students in high-level mental actions. Moreover, deep learning demands full presence from students, encouraging

reflective thinking and application of knowledge in wider and more complex situations (Wang et al., 2023). In contrast to conventional learning approaches that often prioritize outcomes achieved through memorization or basic understanding, deep learning requires students to engage deeply with the subject matter. It is not designed to foster lower-order thinking skills such as remembering or understanding alone but is instead aimed at facilitating the development of higher-order thinking skills including analysis, evaluation, and creation

3.3. The role of teachers in deep learning

Teaching is a process that goes beyond merely delivering information to students. According to Hirst (1971), teaching is an activity aimed at introducing students to a particular body of knowledge or discipline, as well as helping them to understand and master the fundamental concepts within that field. This process involves interaction between teacher and students, in which the teacher does not merely give instructions but also guides learners to think critically and analytically about the knowledge being conveyed. For Hirst, teaching is not merely a matter of practical skills or social activity, but an effort to develop students' intellectual capacities so that they can engage with knowledge more profoundly. Therefore, teaching serves as a means of broadening students' intellectual horizons and equipping them with rational and systematic ways of thinking that are essential for understanding the world around them.

Meanwhile, Suryadi defines teaching as an effort to create didactic situations that stimulate students' mental actions and thereby enable the learning process (Suryadi, 2010). This definition explicitly emphasizes that students are the active subjects undergoing the learning process, while the teacher's role is to guide and create conditions that foster student learning. Teachers play a crucial role in achieving deep learning. In practice, teachers must design learning environments that promote active student engagement in the learning process. This is a key element for forming strong connections between new and existing knowledge. In this context, student activity should not be limited to passive reception of information, but rather involve efforts to process, analyze, and integrate knowledge within contexts relevant to their lives.

Student activities in deep learning may include group discussions, experiments, problem-solving, and other tasks that foster critical and creative thinking. Vygotsky (1978), in his theory of the zone of proximal development, argues that learning occurs most effectively when students interact with others in a supportive context, such as through discussion or group collaboration. These interactions help students deepen their understanding and enhance their thinking. Furthermore, students are not merely positioned as recipients of information, but as active agents in the pursuit of knowledge. Langer (1993) states that a learning approach that facilitates active student involvement allows them to consider various perspectives and construct broader understanding. This underscores the importance of providing space for students to innovate and discover their own ways of applying what they have learned. Thus, student activity in deep learning is not merely physical participation, but also deep mental engagement in the process of understanding and applying knowledge.

The teacher's role in supporting deep learning also involves cultivating a classroom culture characterized by openness, mutual respect, and collaboration. A teacher focused on deep learning will strive to create an inclusive environment where all students feel accepted and valued, and have equal opportunities to grow. Teachers must also provide constructive and supportive feedback, focusing not only on academic achievement but also on personal development. This helps students feel more appreciated and motivated to keep learning.

At its core, deep learning adopts many principles from constructivist learning theory, which posits that knowledge is not passively received but actively constructed by individuals through

experience and interaction with their environment. Consequently, deep learning requires teachers to act as facilitators, with their primary role being to help students become active participants in their learning, connecting prior knowledge with new knowledge and engaging in meaningful learning processes (Shah, 2019). The deep learning environment is characterized by shared knowledge between teacher and student, distributed authority and responsibility, and a redefined teacher role as a guide. In such environments, students are organized into small heterogeneous groups.

In a deep learning context, the teacher gives students the freedom to take initiative and assume responsibility for their learning, while also respecting student autonomy. Teachers utilize diverse learning resources—such as raw data, primary sources, and interactive materials—and encourage students to make use of them. Before conveying their own understanding, teachers first explore students' preconceptions of the concepts being studied. They also promote interaction and dialogue between themselves and students as well as among students, stimulating curiosity through open-ended questions that provoke further discussion. Additionally, the teacher's role is to provide experiences that challenge students' initial understandings, thereby encouraging in-depth discussion. Teachers must also allocate time for students to establish connections among ideas and develop metaphors that enrich their comprehension.

Beyond the three core principles—mindful, meaningful, and joyful learning—there are several teaching principles teachers must consider to create effective learning experiences. One key principle is active engagement. According to Bonwell and Eison (1991), active engagement includes all types of activities that directly involve students in the learning process, such as discussions, problem-solving, or hands-on experiments. Teachers must ensure that students are not merely passive recipients of information but actively participate in the learning process. This kind of engagement not only enhances comprehension but also motivates students to think more critically and creatively.

The second principle is differentiation. Teachers must understand that each student learns differently, and therefore, instruction must be tailored to individual learning needs. Tomlinson (2001) explains that differentiated instruction involves offering a variety of materials, strategies, and assessment methods to ensure that every student can learn in the way that best suits them. For example, for visual learners, teachers can provide learning materials in the form of charts or diagrams, while kinesthetic learners may benefit from physical or hands-on learning activities.

The third principle is positive reinforcement. This principle relates to providing constructive feedback that encourages positive behaviors and academic achievements. Skinner (1953), in his theory of operant conditioning, suggests that positive reinforcement is an effective way to increase the likelihood of behavior repetition. In the teaching context, positive reinforcement can take the form of praise, awards, or positive evaluations of students' efforts and achievements. With the right reinforcement, students will feel more motivated and confident in their learning.

4. Conclusion

Deep learning in the context of elementary education is a strategic approach that emphasizes students' active and reflective cognitive engagement. Grounded in the theoretical foundations of thinkers such as Piaget, Vygotsky, Ausubel, and Langer, this approach prioritizes the construction of knowledge through meaningful experiences, social interaction, and higher-order mental processes.

In practice, the success of deep learning is strongly influenced by the role of teachers as facilitators who can create a responsive, collaborative, and student-centered learning

environment. The use of pedagogical strategies such as discussion, problem-solving, and differentiated instruction fosters the development of critical thinking, creativity, and adaptive skills. Therefore, integrating deep learning at the elementary level not only enhances the quality of the teaching and learning process but also serves as a crucial foundation for preparing a reflective, independent, and competent generation capable of facing the global challenges of the 21st century.

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