Teacher Challenges in Implementing Deep Learning in Elementary Mathematics

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Abstract
The deep learning approach is a learning strategy that emphasizes conceptual understanding, critical thinking, and problem-solving skills. In the context of elementary school mathematics learning, this approach is increasingly important to equip students with meaningful and applicable mathematical competencies in real life situations. However, the implementation of deep learning in mathematics instruction still faces various challenges. This article aims to identify and analyze the barriers to applying the deep learning approach in elementary school mathematics learning. The review was conducted through a literature study of journal articles obtained from Google Scholar. From the initial search results, 12 journal articles were identified that met the inclusion criteria and were suitable for analysis. The findings indicate several obstacles, including limited instructional time that does not support exploratory learning processes, insufficient interactive facilities and media, and teachers' limited understanding of the essence of deep learning. In addition, a curriculum that remains oriented toward procedural memorization and a conservative school culture reinforce resistance to innovative approaches. Students' unpreparedness in dealing with exploratory methods also emerges as a significant challenge. The implications of these findings highlight that implementing deep learning in elementary mathematics requires systemic reforms, including continuous teacher training, strengthened learning infrastructure, and consistent policy support. Consequently, mathematics learning should not only focus on mastering formulas but also foster reflective thinking and contextual problem-solving skills relevant to everyday life.

Keywords:
Deep Learning, Elementary Education, Implementation Issues, Mathematics Learning

1. Introduction

Modern developments marked by technological disruption, social complexity, and the dynamics of globalization have significantly impacted the demands of education. Today's education is no longer solely focused on mastering content; it must also equip students with higher-order thinking skills, such as conceptual understanding, critical thinking, problem-solving, and the ability to apply knowledge in real-world situations (Trilling & Fadel, 2009; OECD, 2018; Sudirman et el., 2022; 2023; 2024). This demand reflects a paradigm shift in learning from passive, teacher-centered approaches to active, contextual, and student-centered learning.

One pedagogical approach for addressing these challenges is deep learning. This approach emphasizes meaningful, reflective, and transformative learning. It fosters deep understanding of material and connects knowledge to students' real lives (Biggs & Tang, 2011; Fullan, Quinn, &

McEachen, 2018). Deep learning encourages active student engagement through cognitively challenging activities, allowing them to construct knowledge independently and collaboratively.

In the context of elementary education, this approach is highly urgent. Elementary education is a crucial stage in laying the foundations for literacy, numeracy, character development and lifelong learning skills. From an early age, students need to be equipped with logical, analytical, and creative thinking skills, which will equip them to face the complex challenges of life in the future (Saavedra & Opfer, 2012; Ministry of Education, Culture, Research, and Technology, 2022). Deep learning, particularly in mathematics, is highly relevant because mathematics is not simply a collection of calculation procedures but also a means of developing systematic thinking, deductive reasoning, and generalization skills that can be applied to various aspects of life.

However, while conceptually this approach promises a more meaningful and effective transformation in learning, its implementation in practice, particularly in primary schools, still faces various challenges. Research indicates that several obstacles hinder the implementation of deep learning, including time constraints during the learning process, a lack of supporting facilities and infrastructure, an inflexible curriculum, and teacher competencies that do not fully support the implementation of deep learning (Darling-Hammond et al., 2020; Permatasari & Nurhasanah, 2021). Furthermore, much of the existing literature still highlights the positive potential of deep learning in general, without much discussion of the specific implementation aspects of specific subjects. Research specifically examining the obstacles to implementing this approach in the context of elementary school mathematics learning is still relatively limited. Yet, a strong mastery of mathematical concepts from an early age is crucial for building students' readiness for scientific thinking and facing future challenges (NCTM, 2014). In other words, there is a significant research gap in the literature regarding the obstacles to implementing deep learning in elementary school mathematics.

Based on this background, this article aims to analyze in-depth the various obstacles to implementing the deep learning approach in elementary school mathematics learning. The study focuses on identifying technical and non-technical inhibiting factors within the school environment. By understanding these obstacles systematically, it is hoped that the results of this study can contribute to formulating more contextual and sustainable implementation strategies, as well as being important input for stakeholders in designing basic education policies that are more responsive to the demands of the times.

2. Method

This research uses a descriptive qualitative approach, aiming to gain an in-depth understanding of the problems and obstacles in implementing a deep learning approach in mathematics learning in elementary schools. This approach was chosen because it is suitable for exploring phenomena contextually and interpretively through a review of relevant literature, without intervention or variable manipulation.

The method used in this research is a literature review using thematic content analysis techniques. Literature reviews allow researchers to review, compare, and synthesize the results of previous research, thus obtaining a comprehensive overview of the topic under study. Thematic content analysis was chosen as the data analysis technique because it allows for the systematic identification of patterns, themes, and key categories from various literature sources. The data sources in this study were obtained from scientific journal articles accessed through the Google Scholar database. To ensure the relevance and relevance of the literature to the study's focus, a search was conducted using the following keywords: “deep learning,” “mathematics,” and “elementary school.” The literature search and selection process was conducted in stages, taking into account several inclusion criteria:

a) Articles must be recent publications, typically published in 2025, to ensure data relevance and relevance to the current educational context.
b) Articles must be empirical research (qualitative, quantitative, or mixed) or theoretical reviews that explicitly discuss the implementation of deep learning approaches in learning contexts.
c) The focus of the study is mathematics.
d) The scope of education studied is primary education.

From the initial search results, 12 journal articles were identified that met the inclusion criteria and were suitable for analysis. The analysis process was conducted manually by creating a thematic table to map the categories of obstacles that emerged. By using this approach and method, the research is expected to provide a more systematic, in-depth, and evidence-based overview of the various obstacles faced in implementing deep learning approaches in mathematics learning at the elementary school level.

3. Results and Discussion

3.1 Results

Based on the analysis of 12 journal articles selected based on inclusion criteria, a number of findings emerged that illustrate various obstacles in implementing the deep learning approach in mathematics learning in elementary schools. The analysis was conducted using a thematic approach to identify key patterns and issues that consistently emerged across various literature sources. In general, the identified obstacles can be grouped into two broad categories: technical and non-technical obstacles. Each category reflects the complexity and interconnectedness of factors that influence the effectiveness of deep learning implementation in elementary schools, particularly in mathematics learning.

Technical obstacles encompass various practical aspects directly related to supporting facilities and infrastructure, learning time, curriculum, and access to technology. These obstacles are both structural and systemic, and often serve as initial barriers that hinder the optimal implementation of innovative, deep learning-based learning strategies. For example, limited time during math lessons makes it difficult for teachers to implement approaches based on concept exploration and in-depth discussions, which are key characteristics of deep learning. The following provides a complete breakdown of technical obstacles in deep learning.

Table 1
Technical Constraints

Description of Constraint	Details
Limited learning time (Purwoko, 2025) (Fitriyasni, 2025) (Warman et al., 2025) (Hayati & Monaliza, 2025) (Nababan et al., 2025) (Mutmainnah, Adrias, & Zulkarnaini, 2025) (Barokah & Mahmudah, 2025)	The time structure in the curriculum is not sufficient for exploratory and in-depth learning that requires a longer duration.
Heavy curriculum load (Purwoko, 2025) (Warman et al., 2025) (Mailani, Rarastika, Jannah, Heriani, & Zendrato, 2025) (Nababan et al., 2025) (Mutmainnah, Adrias, & Zulkarnaini, 2025) (Barokah & Mahmudah, 2025)	The curriculum demands completion of material within a limited time, thus hampering learning innovation.
Limited facilities and learning resources (Fitriyasni, 2025) (Warman et al., 2025) (Hayati & Monaliza, 2025) (Mailani, Rarastika, Jannah, Heriani, & Zendrato, 2025) (Nababan et al., 2025) (Barokah & Mahmudah, 2025) (Mailani, Rarastika, Alfyanti, Purba, Padang, & Ginting, 2025)	Lack of ICT devices, varied learning media, and small classrooms, especially in remote areas.
Limited infrastructure and access to digital technology (Fitriyasni, 2025) (Warman et al., 2025) (Mailania, Rarastika, Saragih, Butar Butar, & Tarigan, 2025) (Hayati & Monaliza, 2025) (Rasma et al., 2025) (Mailani, Rarastika, Jannah, Heriani, & Zendrato, 2025) (Nababan et al., 2025) (Mailani, Rarastika, Pandiangan, Barus, & Sihombing, 2025) (Mutmainnah, Adrias, & Zulkarnaini, 2025) (Barokah & Mahmudah, 2025) (Mailani, Rarastika, Alfyanti, Purba, Padang, & Ginting, 2025)	Uneven internet access, insufficient devices available, and gaps in access between regions or students.
Lack of media or deep learning learning tools (Fitriyasni, 2025) (Hayati & Monaliza, 2025) (Mailani, Rarastika, Jannah, Heriani, & Zendrato, 2025) (Nababan et al., 2025) (Barokah & Mahmudah, 2025)	The lack of interactive technology and concrete tools makes it difficult to implement optimally.
The absence of an adaptive quality assurance system (Mailania, Rarastika, Saragih, Butar Butar, & Tarigan, 2025)	There is no evaluation or quality monitoring system that supports a transformative learning approach.

Description of Constraint	Details
Obstacles to the use of conventional methods which are still dominant (Barokah & Mahmudah, 2025) (Mailani, Rarastika, Alfyanti, Purba, Padang, & Ginting, 2025)	Many schools still rely on old approaches that do not support exploration and reflection.

Non-technical obstacles are more related to pedagogical, psychological, and cultural factors. These include teachers' readiness to adopt new learning paradigms, a lack of understanding of deep learning approaches, and a lack of ongoing professional training. Furthermore, the highly diverse characteristics of elementary school students in terms of learning styles, cognitive abilities, and social backgrounds also pose challenges to implementing meaningful and reflective learning.

Table 2
Non-Technical Obstacles

Description of Constraint	Details
Lack of teacher training in deep learning approaches (Purwoko, 2025) (Warman et al., 2025) (Mailania, Rarastika, Saragih, Butar Butar, & Tarigan, 2025) (Mutmainnah, Adrias, & Zulkarnaini, 2025) (Mailani, Rarastika, Alfyanti, Purba, Padang, & Ginting, 2025)	Teachers are not adequately equipped with pedagogical and technological training to implement in-depth learning strategies.
Teachers' limited understanding of the pedagogical concepts and principles of deep learning (Fitriyasni, 2025) (Hayati & Monaliza, 2025) (Mailani, Rarastika, Pandiangan, Barus, & Sihombing, 2025) (Barokah & Mahmudah, 2025)	Many teachers equate deep learning with ordinary activities, such as discussions without reflection or exploration.
Low teacher readiness as learning facilitators (Warman et al., 2025) (Mailania, Rarastika, Saragih, Butar Butar, & Tarigan, 2025) (Rasma et al., 2025) (Mailani, Rarastika, Jannah, Heriani, & Zendrato, 2025) (Nababan et al., 2025) (Barokah & Mahmudah, 2025) (Barokah & Mahmudah, 2025) (Mailani, Rarastika, Alfyanti, Purba, Padang, & Ginting, 2025)	Teachers are not ready to change their role from teacher to facilitator due to limited pedagogical and digital competencies.
A school culture that is conservative and resistant to innovation (Mailania, Rarastika, Saragih, Butar Butar, & Tarigan, 2025)	The school environment does not support change and innovation in the learning process.
The curriculum is still oriented towards surface learning and memorization (Mailania, Rarastika, Saragih, Butar Butar, & Tarigan, 2025)	Does not yet support the process of exploration, interpretation and transfer of knowledge in a comprehensive manner.
An assessment system that focuses on final results and memorization (Barokah & Mahmudah, 2025)	Minimal application of formative assessment, rubrics, process observations, and student reflection.
Student preferences and readiness for new learning methods (Warman et al., 2025) (Hayati & Monaliza, 2025) (Mailani, Rarastika, Jannah, Heriani, & Zendrato, 2025) (Nababan et al., 2025) (Mutmainnah, Adrias, & Zulkarnaini, 2025) (Barokah & Mahmudah, 2025)	Some students are more comfortable with traditional methods and have difficulty adapting to an exploratory approach.
Ability variation (Fitriyasni, 2025) (Mailani, Rarastika, Jannah, Heriani, & Zendrato, 2025) (Nababan et al., 2025)	Differences in students' backgrounds and readiness to participate in the process of deep thinking and independent learning.
Lack of institutional support and sustainable policies (Mailania, Rarastika, Saragih, Butar Butar, & Tarigan, 2025)	New learning approaches are often only experimental without long-term support from institutions.

Description of Constraint	Details
High administrative demands on teachers (Barokah & Mahmudah, 2025)	Administrative burdens take up teachers' time that could be used to design innovative learning.

3.2 Discussion

Based on the results of a thematic analysis of 12 journal articles reviewed, a number of technical and non-technical obstacles were identified as major barriers to implementing a deep learning approach in mathematics instruction at the elementary school level. These technical obstacles reflect limitations in structural aspects, resources, and systemic support, which directly impact the effectiveness of in-depth, exploratory, and contextual learning.

One of the most frequently cited technical obstacles in the literature is the limited learning time available within the curriculum structure. The deep learning approach requires more time for conceptual exploration, in-depth discussion, and student reflection. However, in practice, the time allocated for mathematics in elementary schools remains very limited. Limited learning time is a major challenge in implementing deep learning, which demands exploration, discussion, and reflection that cannot be accomplished instantly (Arends, 2012). This leads teachers to focus more on achieving curriculum targets than on developing in-depth conceptual understanding (Fitriyani & Sugiarto, 2025; Nugraha, 2025). An overly dense curriculum also poses a significant obstacle. The pressure to complete all teaching materials in a short time makes it difficult for teachers to implement a participatory and reflective approach. As a result, learning tends to revert to mechanistic lectures and practice exercises. However, deep learning demands active student involvement in the thinking and problem-solving process (Rahmawati, 2025; Yuliana & Hakim, 2025). Another obstacle is the lack of adequate learning facilities and support. Many elementary schools, especially in remote areas, still face limitations in terms of the availability of adequate classrooms, varied learning media, and mathematical demonstration tools. These limitations impact students' opportunities to experience active, contextual, and multisensory learning in accordance with deep learning principles (Sari & Mulyana, 2025). The government needs to revise the curriculum structure to provide more space for deep learning approaches. This includes adjusting the time allocation for mathematics subjects and reducing the pressure on solely completing material.

The implementation of deep learning is often associated with the use of digital technology to support interactive, project-based learning. However, unequal access to the internet and technological devices remains a major issue. Many schools lack a stable internet connection or sufficient ICT devices, thus suboptimal integration of technology into learning. Elementary schools, particularly in the 3T (frontier, outermost, and disadvantaged) regions, still experience challenges in terms of internet access, the availability of ICT devices, and digital learning media (Ministry of Education and Culture, 2021). This digital divide also exacerbates disparities in learning outcomes between regions (Latifah & Sudrajat, 2025; UNESCO, 2023). In addition to technological devices, the lack of media or tools that support the deep learning approach is also a challenge. This approach requires concrete or digital tools that can facilitate concept visualization, independent exploration, and problem-solving simulations. Without adequate media, learning tends to be abstract and difficult for students to understand, especially in the context of mathematics (Prasetyo, 2025). Schools, with support from the central and regional governments, need to be equipped with learning facilities that support deep learning approaches, such as ICT devices, interactive media, and concrete aids for visualizing mathematical concepts. Educational development institutions are advised to create accessible, affordable, and teacher-friendly learning media to support students' exploration and reflection. Furthermore, the government needs to promote equitable access to the internet and digital devices, especially in 3T (frontier, outermost, and disadvantaged) areas. This is crucial to ensure fairness in the implementation of digital and exploratory learning.

The lack of a learning evaluation system that supports a transformative approach is also a barrier. Quality assurance and evaluation systems that still focus on final results and written exams do not support deep learning approaches that emphasize students' thinking and reflection (OECD, 2018). This results in deep learning being underutilized in primary school teaching practices (Kemendikbudristek, 2022; Wibowo, 2025). Furthermore, although deep learning approaches have been widely studied and recommended, in practice, many teachers still rely on conventional methods such as lectures and practice exercises. This method is easier to implement and meets the demands of a dense curriculum, but it doesn't support active student engagement in critical and reflective thinking. Reliance on this old method is often a major barrier to learning innovation (Setiawan & Lestari, 2025). A learning monitoring and evaluation system that adapts to new approaches such as deep learning is needed. This system focuses not only on academic achievement but also on the quality of the learning process.

In addition to technical challenges, an analysis of 12 journal articles also revealed various non-technical obstacles that pose significant barriers to implementing a deep learning approach in elementary school mathematics instruction. These non-technical obstacles encompass human factors, organizational culture, policies, and individual and institutional readiness to address the shift in learning paradigms. Unlike technical obstacles, which are more structural and physical in nature, non-technical obstacles are more complex because they relate to the mindsets, attitudes, habits, and values inherent in educational actors, particularly teachers and students.

One major obstacle is the lack of training specifically equipping teachers with the pedagogical and technological competencies necessary to implement a deep learning approach. Most teachers have not received adequate training in deep learning pedagogy, including exploratory classroom management strategies and the use of digital technology (Darling-Hammond et al., 2017). This results in poor implementation quality in the classroom. Many teachers have limited or even misunderstandings about deep learning. Teachers often equate deep learning with traditional active methods without an emphasis on reflection or connections between concepts (Biggs & Tang, 2011). This has led to misconceptions about its implementation. Some consider it merely a form of group discussion or exploratory activity without a clear reflective purpose. This misunderstanding leads to the implementation of deep learning strategies not being fully implemented in accordance with proper pedagogical principles (Rahmawati, 2025). The implementation of deep learning requires the teacher to act as a facilitator, not just a transmitter of information. However, many teachers are not ready to fulfill this role due to limited competency in facilitating critical discussions, guiding students' independent exploration, and utilizing technology to support the process. This role transition requires a challenging mindset shift. Teachers need training that is not only technical but also touches on the pedagogical dimensions of deep learning, such as facilitating reflective discussions, project-based learning, and authentic assessment. Teacher capacity building programs should focus on deepening the concept of deep learning, so that teachers do not equate this approach with ordinary discussion or group work activities. Assistance is needed in changing the role of teachers from "transmitters of information" to learning facilitators who encourage critical thinking and student independence.

Elementary school teachers face a significant administrative burden, from daily reports and data entry to performance reporting. This burden consumes teachers' time and energy, making it difficult for them to optimally design, implement, and reflect on deep learning-based instruction. Teachers tend to choose quick and practical strategies (Ministry of Education, Culture, Research, and Technology, 2023). The government and education offices need to reevaluate teachers' administrative burdens, which often distract them from designing and implementing innovative learning. Digitization and reporting simplification could be an initial solution.

School environments that tend to maintain old practices and are reluctant to change also present significant obstacles. Resistance to changes in learning methods is a significant obstacle, especially if the principal and the work environment do not support innovation (Fullan, 2007). Conservative organizational cultures prevent teachers' initiatives to implement innovative learning, such as deep learning, from receiving insufficient support. Innovative learning approaches, such as deep learning, are often implemented only experimentally or on a short-term project basis. The lack of sustained policy support from both schools and local governments makes it difficult to sustain emerging good practices in the long term. In some cases, innovation is perceived as disruptive to the regularity of the existing learning process. Principals and policymakers at the institutional level need to create a school climate that is open to innovation and supports pedagogical experimentation without fear of failure.

Structurally, the basic education curriculum in Indonesia still tends to emphasize material acquisition and memorization, rather than conceptual understanding and knowledge transfer. This is inconsistent with the principles of deep learning, which emphasize the depth, relevance, and meaning of learning (Kemendikbudristek, 2022). The evaluation system used in many schools is still oriented towards final results in the form of numbers or cognitive scores. Process assessment, formative assessment, or the use of reflective rubrics has not been widely implemented. As a result, deep learning, which emphasizes thinking processes and exploration, has little place in the assessment system. Assessment systems need to be directed toward formative approaches, learning processes, and the development of 21st-century competencies. Rubric-based assessment, observation, and reflection should be gradually implemented.

Some students show resistance to deep learning approaches because they are accustomed to more structured and direct traditional learning models. Exploratory approaches that require initiative and critical thinking often make them feel uncomfortable or confused (Bransford et al., 2000). Students' levels of readiness and thinking skills vary widely. Students with low literacy and numeracy skills struggle with learning processes that rely on exploration and reflective thinking. Without adequate strategy differentiation, deep learning approaches risk widening gaps between students. Teachers need to be encouraged to implement differentiated learning strategies to prevent varying student abilities from becoming barriers to in-depth learning.

These two types of obstacles are not isolated but interconnected, forming a complex ecosystem. Technical obstacles, if not properly addressed, can exacerbate non-technical challenges, and vice versa. Therefore, a comprehensive understanding of these two categories is crucial for formulating an effective and contextualized deep learning implementation strategy, particularly in elementary school mathematics instruction.

4. Conclusion

This study aims to systematically analyze the various obstacles to implementing a deep learning approach in mathematics instruction at the elementary school level. Through a thematic analysis of 12 relevant journal articles published in 2025, this study identified various obstacles, both technical and non-technical, that significantly hamper the integration of deep learning into early mathematics instruction. These findings enrich understanding in elementary education by providing a more in-depth picture of the complex obstacles faced by teachers and schools in implementing deep learning-based learning strategies. From a technical perspective, obstacles such as time constraints, a dense curriculum, limited facilities, disparities in technology access, and the absence of an adaptive quality assurance system are key factors. Meanwhile, from a non-technical perspective, challenges such as a lack of teacher training, misconceptions about the concept of deep learning, a conservative school culture, an assessment system that does not support deep thinking, and low student and institutional readiness are also significant obstacles.

The scientific contribution of this study lies in emphasizing that successful implementation of deep learning cannot be achieved through pedagogical innovation alone, but requires comprehensive, systemic support—including curriculum reform, teacher professional development, assessment system restructuring, and sustained policy support. Further research is recommended to develop contextualized intervention models to address both sets of constraints, particularly in schools with limited resources. Classroom-based experimental studies that test the effectiveness of deep learning strategies, and long-term tracking of their impact on student achievement and mindset, would provide a strong empirical basis for supporting educational policy. Furthermore, a collaborative research approach between teachers, principals, and curriculum developers could also generate a practical framework for the sustainable and effective integration of deep learning at the primary education level.

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