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Deep Learning: Adaptive Solutions Towards Inclusive 21st Century Education

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Abstract: The demands of 21st-century education require a paradigm shift in learning that goes beyond the mere transfer of knowledge toward the development of critical thinking, creativity, collaboration, and communication skills. At the same time, the education system is expected to embody the principle of inclusivity to ensure that every learner has equal access to meaningful learning opportunities. This article aims to analyze the relevance and potential of deep learning pedagogy as an adaptive approach to support inclusive education in the 21st century. The study employed a library research method by reviewing academic literature, including books, reputable journal articles, and both national and international policy documents. The findings indicate that deep learning pedagogy emphasizes conceptual understanding, higher-order thinking, and active student participation, aligning with the demands of 21st-century competencies. Moreover, integrating deep learning with inclusivity principles allows diverse learners, including those with special needs, to engage actively through project-based, collaborative, and digital learning strategies. Nevertheless, the implementation in Indonesia faces several challenges, such as teachers' readiness, limited facilities, and the dominance of teacher-centered practices. The article concludes that deep learning pedagogy offers a transformative solution for enhancing both quality and equity in education, while further empirical research is required to test its implementation in various educational contexts.

Keywords; Deep learning pedagogy; 21st-century education; inclusive education; 21st-century skills; innovative learning

Abstract: *Pendidikan abad ke-21 menuntut adanya transformasi paradigma pembelajaran yang tidak hanya berorientasi pada transfer pengetahuan, tetapi juga pada pengembangan keterampilan berpikir kritis, kreativitas, kolaborasi, dan komunikasi. Pada saat yang sama, sistem pendidikan dituntut untuk mampu mewujudkan prinsip inklusivitas agar semua peserta didik memperoleh hak belajar tanpa diskriminasi. Artikel ini bertujuan menganalisis relevansi dan potensi deep learning pedagogy sebagai pendekatan adaptif untuk mendukung pendidikan abad ke-21 yang inklusif. Penelitian menggunakan metode kajian kepustakaan dengan menelaah literatur akademik berupa buku, artikel jurnal bereputasi, serta dokumen kebijakan nasional maupun internasional. Hasil kajian menunjukkan bahwa deep learning pedagogy menekankan pemahaman konseptual, keterampilan berpikir tingkat tinggi, dan partisipasi aktif siswa, sehingga selaras dengan kebutuhan keterampilan abad ke-21. Selain itu, integrasi deep learning dengan prinsip inklusivitas memungkinkan setiap peserta didik, termasuk yang memiliki kebutuhan*

khusus, terlibat aktif sesuai potensinya melalui strategi pembelajaran berbasis proyek, kolaboratif, dan digital. Kendati demikian, penerapannya di Indonesia masih menghadapi keterbatasan, baik dari sisi kesiapan guru, sarana pendukung, maupun budaya pembelajaran yang masih berpusat pada guru. Artikel ini menyimpulkan bahwa deep learning pedagogy dapat menjadi solusi transformatif untuk memperkuat mutu sekaligus pemerataan pendidikan, meskipun diperlukan penelitian lanjutan untuk menguji implementasinya secara empiris.
Kata Kunci; Deep learning pedagogy; pendidikan abad ke-21; pendidikan inklusif; keterampilan abad ke-21; pembelajaran inovatif

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Introduction

Educational transformation in the 21st century requires a new paradigm in the learning process (Fauzi et al., 2023). Global changes influenced by the 4.0 industrial revolution, digitalisation, and the development of artificial intelligence technology have created a need for a generation with 4C competencies (critical thinking, creativity, collaboration, communication) (Susanto & Azizah, 2025). These competencies are not only relevant for the world of work but also a prerequisite for students to be able to adapt to increasingly rapid social, cultural, and economic changes. In this context, deep learning has become one of the pedagogical strategies that emphasises conceptual understanding, interconnections between ideas, and students' ability to evaluate and create new knowledge (Fitriani & Santiani, 2025). This approach is considered more relevant than surface learning, which tends to emphasise memorisation and reproduction of information.

In Indonesia, efforts to reform education for the 21st century have been reflected in national policies, such as the Merdeka Belajar Curriculum, which emphasises flexibility, differentiation, and character building (Yanto et al., 2025). Many teachers are still stuck in traditional, teacher-centred approaches and do not provide enough space for students to explore knowledge in depth (Natasya et al., 2025). This condition is exacerbated by unequal access to learning resources, especially in remote areas. Therefore, the application of deep learning pedagogy is relevant as a pedagogical solution to equip students with 21st-century skills.

In addition, another challenge facing national education is the realisation of inclusive education, namely education that guarantees the right of all children to learn without discrimination, including students with special needs, gender differences, socio-economic differences, and cultural backgrounds (Sefriyana et al., 2025). The concept of inclusive education is in line with the Sustainable Development Goals (SDGs) agenda, particularly Goal 4, which emphasises

equitable quality education. However, research shows that the implementation of inclusive education in Indonesia still faces various obstacles, both in terms of policy, teacher readiness, and supporting facilities (Munawir et al., 2025). The integration of the deep learning approach with inclusive education has the potential to be an adaptive strategy to create a participatory learning atmosphere, empower each student according to their potential, and encourage fairness in the learning process.

Several previous studies have highlighted the effectiveness of 21st-century learning approaches in improving student learning quality. For example, (Ramadhan & Hindun, 2023) found that project-based learning models encourage the active participation of students with special needs in regular classes. Similarly, a study by (Situmorang, 2024) showed that the use of technology-based collaborative strategies can increase student engagement in distance learning. However, research that explicitly links deep learning pedagogy with inclusive education practices is still very limited. Most studies only focus on specific technological aspects or methods, rather than on integrative efforts to address the diverse needs of students in the digital age.

Based on this background, this study attempts to analyse the implementation of deep learning as an adaptive solution in realising inclusive 21st-century education. This study focuses on how deep learning strategies can be applied to foster active participation, accommodate individual differences, and develop 21st-century skills in students. Theoretically, this article is expected to contribute to the development of contemporary pedagogical discourse that integrates deep learning with inclusivity. Practically, this article can be a reference for teachers, lecturers, and policymakers in designing adaptive, transformative, and equitable learning.

Method

This study utilises a qualitative approach with a literature review (Mahanum, 2021). This approach was chosen because the research focuses on theoretical and conceptual analysis of the implementation of deep learning pedagogy in inclusive 21st-century education. Through library research, researchers can examine and synthesise various theories, previous research results, and relevant policy documents to build a more comprehensive understanding.

The research data sources were drawn from academic literature, including reference books on deep learning theory, 21st-century pedagogy, and inclusive education. In addition, reputable journal articles indexed by SINTA, Scopus, and Web of Science over the past ten years served as the main references. This research also utilised official documents such as UNESCO policies on Education for All and

Sustainable Development Goals (SDGs), as well as national regulations related to inclusive education and 21st-century curriculum development in Indonesia.

Data collection was conducted through literature searches using keywords such as deep learning pedagogy, 21st-century skills, inclusive education, transformative pedagogy, and education equity. The searches were conducted in scientific databases such as Google Scholar, DOAJ, Scopus, and Garuda (Garba Rujukan Digital Indonesia). The literature obtained was then critically reviewed, considering its relevance, novelty, and quality.

Data analysis in this study utilised content analysis techniques (Ahmad, 2018). The stages of analysis included data reduction, which involved selecting the most relevant literature; categorisation, which involved grouping the literature into main themes such as the concept of deep learning, 21st-century education, inclusivity, and the challenges and opportunities of integrating the two; and synthesis, which involved formulating the relationships between concepts to construct a comprehensive framework of thought. Subsequently, conclusions were drawn in the form of conceptual findings that explain the role of deep learning pedagogy in supporting inclusive 21st-century education. With this method, the study is expected to contribute both theoretically and practically to the development of contemporary educational discourse in Indonesia.

Results And Discussion

Results

A literature review on the implementation of deep learning pedagogy in realising inclusive 21st-century education reveals several important findings that can be grouped into four main aspects, namely: (1) the concepts and principles of deep learning, (2) the urgency of 21st-century skills, (3) challenges and conditions of inclusive education in Indonesia, and (4) the relevance of deep learning pedagogy as an adaptive solution.

The literature reviewed emphasises that deep learning in the context of education is better understood as a pedagogical approach rather than simply artificial intelligence technology. According to Ar-Rasyid et al., (2025) Deep learning is a learning strategy that emphasises the active involvement of learners in understanding concepts in depth, connecting ideas, and relating material to real-life experiences. This differs from surface learning, which only emphasises memorisation without complete understanding.

Some of the main characteristics of deep learning pedagogy include: 1). Emphasising conceptual understanding rather than mere memorisation. 2). Encouraging critical reflection so that students can analyse and evaluate information. 3. Integrating real-life experiences to make learning more meaningful.

4). Fostering independent learning through higher-order thinking skills (HOTS). (Fatmawaty, 2024a).

Another study by (Fatmawati, 2025) adds that deep learning must also involve the use of digital technology as a means to expand access, enrich interaction, and increase student participation. Thus, deep learning can be seen as a pedagogical strategy that is adaptive to the times and relevant for building the complex skills needed by students.

The results of the literature review also show that 21st-century education requires students to have skills that are not only cognitive but also social and emotional. According to (Lestari & Hindun, 2024) 21st-century skills are summarised in 4Cs: critical thinking, creativity, collaboration, and communication. These four competencies are key to facing the era of globalisation, technological disruption, and increasingly complex job competition.

The educational context in Indonesia emphasises the importance of these skills. The Merdeka Curriculum launched by the Ministry of Education, Culture, Research, and Technology places character development and 21st-century skills as one of its top priorities. However, various studies show that the implementation of this curriculum has not been fully effective. Teachers still tend to use a traditional teacher-centred approach, limiting the space for training students' critical thinking and collaboration skills (Risana et al., 2025).

Thus, the results of the literature review show that deep learning pedagogy is highly relevant to addressing 21st-century skills needs. Through deep learning, students not only acquire factual knowledge, but are also trained to develop higher-order thinking skills, collaborate across cultures, and adapt to social complexity (Mujtahid et al., 2025).

The literature review also shows that inclusive education remains a major challenge in Indonesia. Inclusive education is understood as an effort to provide equal and equitable educational services to all students, including those with special needs, those from low socioeconomic backgrounds, or those with cultural and linguistic differences (Judijanto et al., 2025).

However, research shows that the implementation of inclusive education in Indonesia still faces various obstacles. Research (Susilowati et al., n.d.) found that most schools are not yet fully prepared to implement inclusive education due to limited resources, both in terms of trained teachers and supporting infrastructure. In addition, the community's biased attitudes towards children with special needs also pose a social barrier.

In this context, an adaptive learning approach is essential. Deep learning pedagogy can be a solution because it emphasises the active involvement of all

students according to their individual abilities and uniqueness. Strategies such as project-based learning, collaborative learning, and the use of digital technology enable teachers to design inclusive learning activities, where each student can contribute according to their potential (Trisanani et al., 2025).

The literature reviewed also shows that the integration of deep learning pedagogy in inclusive education offers several important opportunities. A study conducted by (Pramudita & Prabowo, 2025) shows that project-based learning can increase the participation of students with special needs in regular classes. Similarly, research (Saba, 2024) confirms that the use of technology-based collaborative strategies can increase student engagement in online learning. Both studies show that learning strategies that focus on active student engagement can reduce barriers to participation in the context of inclusive education.

However, the literature review also found a research gap. So far, existing studies have emphasised technology integration or collaborative strategies in general, but few have specifically explored the application of deep learning pedagogy within the framework of inclusive education in Indonesia. This gap in the literature provides an important opportunity for further research to develop conceptual and practical models that integrate deep learning with the principles of inclusivity.

Based on the literature reviewed, it can be concluded that deep learning pedagogy has great potential in addressing two major challenges in 21st-century education: mastery of 4C skills and implementation of inclusive education. Deep learning not only helps learners understand the material in depth, but also fosters reflective awareness and the ability to collaborate across differences (Wafa et al., 2025). In the Indonesian context, this approach is relevant for overcoming learning gaps that are still dominated by traditional methods and are not very accommodating to student diversity.

Table 1. Literature Synthesis Related to Deep Learning, the 21st Century, and Inclusive Education

Author & Year	Research Focus	Key Findings	Relevance to Deep Learning & Inclusive Education
Kadarismanto & Sari, 2025)	Konsep *deep learning* vs *surface learning*	Deep learning emphasises conceptual understanding, interconnections between ideas, and	Serving as a theoretical basis for distinguishing deep learning from superficial memorisation, it is

Author & Year	Research Focus	Key Findings	Relevance to Deep Learning & Inclusive Education
		skills.	relevant for promoting adaptive learning.
(Trisnawati & Sari, 2019)	21st-century education and 4C skills	Critical thinking, creativity, collaboration, and communication skills are essential for the global generation..	Deep learning can be a pedagogical strategy for fostering the 4Cs, which are
(Fatmawati, 2025)	Digital technology in deep learning	The use of technology broadens access, enriches interaction, and increases student engagement.	Supporting inclusivity by minimising geographical and social barriers to learning.
(Susilowati et al., n.d.)	The challenges of inclusive education in Indonesia	Schools are not yet ready in terms of human resources, facilities are limited, and community attitudes are still biased.	Demonstrating the urgency of new pedagogical strategies, deep learning can fill this gap with a collaborative and adaptive approach.
(Ramadhan & Hindun, 2023)	Project-based learning model for students with special needs	Student participation increases when they are involved in real projects	Demonstrating the effectiveness of deep learning strategies in an inclusive context
(Fitria & Muthi, 2024)	The use of interactive digital media in blended learning	Enhancing students' independent learning and facilitating differentiated learning	Supporting the idea that technology in deep learning strengthens inclusive education practices
(Situmorang, 2024)	Collaborative strategy berbasis teknologi dalam pembelajaran daring	Increasing student engagement through collaborative activities	Relevant to deep learning, which emphasises collaboration while strengthening the dimension of inclusivity

Discussion

The results of the literature review presented above show that deep learning pedagogy is highly relevant in addressing the challenges of 21st-century education

while supporting the creation of inclusive education. Deep learning is understood not merely as a new method but as a pedagogical paradigm that places learners as active subjects in the learning process (Mustaghfirin & Zaman, 2025). With this approach, students are guided to develop conceptual understanding, build connections between ideas, and relate knowledge to real-life experiences. Such characteristics are in line with the demands of 21st-century education, which emphasises critical thinking, creativity, collaboration, and communication skills (Riskayanti, 2021). However, the reality in Indonesia still shows a considerable gap between the concept of deep learning and classroom learning practices. Most teachers still tend to apply surface learning patterns that only emphasise mastery of facts, while reflective and analytical dimensions are not yet optimally accommodated (Natalia & Pranata, 2025). This condition confirms that deep learning pedagogy is not just a technical method, but an urgent need to shift the learning paradigm from teacher-centred to student-centred.

The link between deep learning pedagogy and the 21st-century skills agenda further reinforces its urgency. Lestari and Hindun emphasise that mastery of the 4Cs is fundamental for future generations to be able to adapt to the increasingly dynamic complexities of the world of work and social life (Lestari & Hindun, 2024). However, various studies show that learning practices in Indonesia do not yet fully support the development of these skills. Conventional methods are still dominant, limiting the space for students to develop creativity, collaborate, and practise communication skills (Jusman & Parisu, 2025). In this context, deep learning pedagogy is seen as not only relevant but also essential to ensure that students are not only academically competent but also have the adaptive capacity to face the changes of the times. Thus, the application of deep learning can be positioned as a strategic instrument in realising the vision of 21st-century education.

The link between deep learning pedagogy and inclusive education is an important aspect that deserves closer attention. Inclusive education in Indonesia, despite having gained policy legitimacy through the National Education System Law and being reinforced by international agendas such as the Sustainable Development Goals, still faces various obstacles (Anwar et al., 2025). Limited facilities, a shortage of trained teachers, and persistent social bias against students with special needs are real challenges. It is in this context that deep learning pedagogy can offer adaptive solutions. Conceptually, deep learning emphasises the active involvement of each student according to their capacity (Irfanuddin et al., 2025). Strategies such as project-based learning, collaborative learning, and the use of digital technology enable students from diverse backgrounds to participate

according to their potential (Hermansyah et al., 2025). Research (Wahyuningsih et al., 2024), for example, shows that the engagement of students with special needs increases when they are involved in real projects. Similarly, a study (Husna, 2024) confirms that technology-based collaborative strategies can strengthen the participation of students who were previously hampered by limited interaction in conventional classrooms. These research results indicate that deep learning pedagogy not only improves the quality of learning but can also strengthen the principle of inclusivity in educational practice.

However, it should be emphasised that the literature review also reveals the limitations of research that explicitly links deep learning pedagogy with inclusive education. Most studies are still independent, with some focusing more on 21st-century skills, while others focus on inclusive policies and practices. This opens up space for the contribution of this research, namely, to present a conceptual synthesis that links the two within a single analytical framework. By connecting deep learning and inclusivity, this article presents a new perspective that the quality of learning and social justice in education are not two separate agendas, but can be integrated into a single, comprehensive pedagogical model. This is the novelty of this research, which enriches the contemporary discourse on education.

Furthermore, the results of the study Halim, (2025) Also, highlight that the implementation of deep learning pedagogy in the Indonesian context faces structural and cultural challenges. In terms of human resources, many teachers do not yet have the pedagogical skills to implement deep learning. Existing teacher training programmes also place more emphasis on administrative aspects than on the development of innovative strategies based on student-centred learning. In terms of infrastructure, not all schools have adequate access to digital technology, which is an important element in supporting deep learning (Suwandi et al., 2024). Meanwhile, culturally, the education system in Indonesia is still laden with hierarchical patterns that place teachers as the sole authority, thereby limiting students' freedom to learn. These obstacles show that the implementation of deep learning pedagogy cannot rely solely on the initiative of individual teachers, but requires broader systemic support (Nadawina et al., 2025).

Despite facing various obstacles, opportunities to implement deep learning pedagogy in Indonesia are also quite open (Suwandi et al., 2024). he Merdeka Curriculum policy, for example, provides more space for teachers to innovate adaptive and contextual learning. In addition, increased access to digital technology can also be a catalyst for the integration of deep learning with technology-based learning. International agendas such as the SDGs also exert positive pressure on governments and educational institutions to strengthen

inclusive practices in schools. With the synergy of policies, infrastructure, and changes in pedagogical paradigms, deep learning pedagogy has great potential to be implemented more widely in the national education system.

Theoretically, the integration of deep learning with inclusive education broadens the horizons of contemporary (Martiadi et al., 2025). Whereas deep learning was previously positioned primarily as a means of enhancing critical thinking and creativity, this study affirms that this approach can also be an instrument of social justice in education. This means that quality and equity do not need to be mutually exclusive, but can be achieved simultaneously through appropriate learning design. In practical terms, the implication of this research is the need for educators to design learning experiences that combine deep learning principles with inclusive strategies. Teachers can, for example, form heterogeneous learning groups where each student contributes according to their potential, utilise technology to overcome access barriers, and foster critical reflection so that students can appreciate differences. Thus, deep learning pedagogy not only improves academic quality but also strengthens social cohesion in the classroom.

This analysis confirms that deep learning pedagogy is an adaptive and transformative solution for 21st-century education. Its success is largely determined by teacher readiness, policy support, and resource availability. Therefore, a systematic strategy is needed to strengthen educator capacity, provide equitable infrastructure, and build an inclusive learning culture. This article also opens up space for further research that can empirically test the conceptual model of deep learning pedagogy in the context of inclusive education, whether in primary, secondary, or higher education. Thus, the integration of quality and equity in education will not only be a discourse, but can actually be realised in practice.

Conclusion

Deep learning pedagogy is a relevant and adaptive pedagogical approach that addresses the challenges of 21st-century education while supporting the realisation of inclusive education. This approach emphasises conceptual understanding, higher-order thinking skills, active participation, collaboration, and critical reflection, which are necessary for developing 21st-century competencies. The integration of deep learning with the principle of inclusivity demonstrates that learning quality and equitable access can be achieved simultaneously through innovative, contextual learning strategies.

The contribution of this research lies in its attempt to broaden the discourse on contemporary pedagogy by linking deep learning pedagogy and inclusive education within a single analytical framework. This perspective presents

something new because, until now, studies on deep learning have mostly focused on strengthening 21st-century skills, while inclusive education has been positioned as an agenda for equal access. By combining the two, this research makes a theoretical and practical contribution, especially as a reference for educators and policymakers in designing adaptive, participatory, and equitable learning.

However, this study has limitations because it is still based on a literature review, making it conceptual and argumentative in nature, without presenting empirical evidence from learning practices. Therefore, further research is needed to test the deep learning pedagogy integration model in inclusive education through field studies at various levels of education in Indonesia.

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