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Deep Learning Based Educational Transformation as a Roadmap to *Indonesia Emas* 2045

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ABSTRACT

The vision of Indonesia Emas 2045 emphasizes the development of superior human resources (HR) who are globally competitive and possess moral and social integrity. In this context, the paradigm of national education needs to undergo a fundamental transformation. This article proposes the deep learning approach as a pedagogical strategy that supports the achievement of the Indonesia Emas 2045 roadmap. Unlike conventional learning models that tend to emphasize memorization, deep learning focuses on deep understanding, critical reflection, and the application of knowledge in real-world contexts. Through a conceptual study, this article elaborates on the relevance of deep learning in strengthening the quality of human resources, integrating it with the stages of national development, and offering innovative and revolutionary ideas for the implementation of education in Indonesia.

Introduction

Indonesia is projected to become one of the world's major economic powers by 2045, coinciding with the centenary of its independence. Various international projections indicate that Indonesia has the potential to be among the world's top five economies, with a Gross Domestic Product (GDP) reaching approximately USD 7.3 trillion and a per capita income of over USD 25,000 (Bappenas, 2019). However, this ambitious target can only be achieved if the nation succeeds in developing high-quality human resources (HR) who are adaptive to global dynamics and possess strong innovation capacity and competitiveness. Therefore, the development of human resource quality is placed as a top priority in the National Long-Term Development Plan (RPJPN) 2025–2045 (Law No. 59 of 2024).

Nevertheless, Indonesia's education system still faces fundamental challenges. The results of the Programme for International Student Assessment (PISA) 2022 show that Indonesian students' literacy, numeracy, and science skills remain below the OECD average ("PISA 2022 Results (Volume I)," 2023). In addition, there is a significant gap in education quality across regions, particularly between urban and rural areas (*World Development Report 2021: Data for Better Lives*, 2021). Furthermore, learning practices in many schools and universities remain oriented toward rote memorization and standardized testing, which fail to cultivate 21st-century skills such as critical thinking, creativity, collaboration, and digital literacy (Afriani, 2024).

 ISSN 2747-089X

Transformative Education Paradigm Based on Deep Learning to Realize Indonesia's Golden Vision 2045

a. The Concept of Deep Learning in Education

Deep learning in education is a paradigm that emphasizes deep understanding, the interconnectedness between concepts, and students' ability to integrate knowledge with real-life contexts (Khairi et al., 2023). Muvid (2024) asserts that deep learning is the antithesis of surface learning, which tends to focus on memorization and repetition. In the deep learning approach, students are viewed as active learners who construct meaning through critical, reflective, and creative thinking processes.

Syi'bul Huda et al., (2025) add that the international discourse on the deep learning curriculum has experienced rapid growth over the past five years, particularly since 2020. Recent studies not only highlight pedagogical aspects but also explore technological integration, curriculum strategies, and the use of multi-agent reinforcement learning. This indicates that deep learning has evolved from a mere pedagogical approach into a mainstream trend in global educational reform. In a case study, Yusriati and Mardiati (2025) explain that Finland places innovation and sustainability at the core of its educational transformation process. Technology is strategically integrated into the national curriculum through the use of digital tools and online learning platforms, enabling learning to become more flexible and personalized. Singapore implements an education strategy focusing on digital competencies and data-driven learning to improve the quality of education. Through the Smart Nation Initiative, technology is integrated into all elements of education, from the curriculum to student data management. This approach has proven effective in enhancing academic achievement and preparing students for a modern, technology-driven workforce. This shows that the deep learning approach has been applied in many countries, demonstrating relevant progress and outcomes in improving the quality of understanding and student engagement.

In the context of Indonesia, the implementation of deep learning is essential to address the weaknesses of an education system still trapped in traditional, rote-based methods. The challenges of low literacy and numeracy, disparities in teacher quality, and weak critical thinking skills among students highlight the urgent need for curriculum transformation toward deep learning. Therefore, the concept of deep learning is not only academically relevant but also strategically significant in the context of national development.

The deep learning approach is based on three conceptual pillars. First, mindful learning emphasizes the awareness that each learner has different backgrounds, needs, and learning styles. Therefore, teachers need to build intensive interaction and positive relationships with students, offer full respect, and acknowledge individual differences in thinking and learning styles. Second, meaningful learning refers to a learning process that is engaging and meaningful, where students are encouraged to think critically, actively participate in learning activities, and understand the meaning of the material in a deep and contextual way. Third, joyful learning focuses on creating enjoyable and relevant learning experiences. Joy arises when students feel appreciated, have opportunities to learn independently, discover new things, and gain new understanding from the material being studied (Diputera et al., 2024).

These three conceptual pillars are highly relevant to fulfilling the aspiration of producing the Golden Generation. Through mindful learning, young people are shaped into self-aware individuals who respect diversity and can collaborate effectively. Meaningful learning cultivates critical and creative thinking skills essential for innovation, while joyful learning fosters intrinsic motivation and resilience for lifelong learning. The synergy among these three pillars forms the foundation for developing human resources who are adaptive, have strong character, and are globally competitive.

b. Deep Learning and the Strengthening of 21st-Century Competencies

The concept of 21st-century skills emerged as a response to the dynamics of globalization, technological advancement, and the demand for a workforce that possesses competencies beyond mere academic knowledge. Modern education is required not only to transfer knowledge but also to develop skills that are relevant to the demands of the contemporary era. Therefore, 21st-century skills serve as a crucial foundation in shaping a generation that is adaptive, collaborative, and ready for transformation (Siprianus Jewarut et al., 2025).

Education in the 21st century demands not only mastery of content but also higher-order thinking skills, creativity, communication, collaboration, and digital literacy. Iriawan (2017) states that 21st-century competencies are divided into three domains: basic literacy (reading, numeracy, science, digital), cognitive competencies (the 4Cs: critical thinking, creativity, communication, collaboration), and character qualities (leadership, adaptability, social awareness).

The deep learning approach aligns closely with this framework. Through project-based learning, collaborative discussions, and problem-solving activities, students are trained not only to master knowledge but also to apply it creatively in solving real-world problems (Suwandi et al., 2024). The Ministry of Education, Culture, Research, and Technology (Kemendikbudristek, 2022), in the *Merdeka Curriculum* guidelines, emphasizes the importance of differentiated learning, cross-disciplinary projects, and authentic assessment—all of which are consistent with deep learning's focus on meaningful engagement and active participation.

However, the implementation challenges are not insignificant. Many teachers remain exam-oriented, while learning facilities in underdeveloped regions still do not adequately support deep learning practices (Antoninis et al., 2023). Turmuzi (2025a) highlights that the integration of artificial intelligence–based technology can help overcome some of these barriers. Intelligent learning systems are capable of analyzing students' learning styles, providing automatic feedback, and even personalizing materials to meet individual needs. Through this approach, deep learning can effectively optimize the strengthening of 21st-century competencies.

c. Demographic Bonus and the Urgency of Transformative Education

Indonesia is projected to experience the peak of its demographic bonus between 2030 and 2045, when the proportion of the productive-age population will exceed 64% (Nuriman et al., 2025). This condition could become a golden opportunity if the human resources produced possess global competencies, but it could also turn into a social disaster if not addressed through the right educational strategies.

The World Bank (2020) reminds that although school participation rates in Indonesia have increased, the quality of learning remains a serious issue. More than 70% of Indonesian students failed to meet the basic literacy standards in PISA 2018, indicating that many children attend school but do not actually learn. This statement reinforces the urgency of transformative education that focuses on learning outcomes rather than mere classroom attendance.

In this context, deep learning serves as a strategic response to harness the demographic bonus. By emphasizing critical thinking, digital literacy, and creativity, a curriculum based on deep learning can cultivate a productive generation that is not only ready to work but also capable of creating jobs. Transformative education grounded in the principles of deep learning will ensure that the surge in the productive population truly becomes a demographic dividend that benefits the nation (Prawiyogi & Rosalina, 2025).

d. Deep Learning, HOTS, Literacy, and Numeracy

One of the fundamental problems in Indonesian education is the low achievement levels in literacy and numeracy among students. Deep learning, as an innovative learning approach, plays an important role in developing students' numeracy skills (Luqmanul Hakim et al., 2022). Hafidzni et al. (2025) emphasize that deep learning integrated with HOTS (Higher Order Thinking Skills) can elevate students' abilities to higher levels of cognition—analyzing, evaluating, and creating. This is crucial considering that PISA results show most Indonesian students remain at the

 ISSN 2747-089X

lower order thinking level. Hasdiana Hadjaratie, L. Masaong et al. (2023), in their article *Preparing the Golden Generation 2045 through Creativity-Based Learning*, also assert that creativity is a key skill for facing global disruption. Deep learning supports creativity development by emphasizing collaborative projects, exploration, and open-ended problem solving. Thus, students not only understand the material but are also capable of generating new and applicable ideas.

Adnyana, (2024) adds a technological dimension to deep learning. By utilizing artificial intelligence, learning can be personalized so that students with different learning styles still gain meaningful learning experiences. For instance, AI-based virtual tutors can recommend materials, quizzes, or learning methods that best suit each individual. This not only increases learning effectiveness but also opens up opportunities to create a more inclusive education system.

e. The Urgency of a Deep Learning Curriculum for the Indonesia Emas 2045 Roadmap

The vision of Indonesia Emas 2045 aims for Indonesia to become one of the world's major economic powers, driven by excellent human resources. Muvid (2024) emphasizes that deep learning is an extension of constructivism that can strengthen the implementation of the *Merdeka Curriculum*. This aligns with the view of Huda et al. (2025), who note that the deep learning curriculum has now become a global trend moving toward evolutionary curricula, advanced vocational education, and the integration of cutting-edge technology.

A curriculum based on deep learning serves as a strategic instrument to address the challenges of the demographic bonus while simultaneously resolving the crises in literacy and numeracy. Hafidzni et al. (2025) affirm that its implementation can enhance students' conceptual understanding, while Turmuzi (2025) demonstrates that AI-based systems are capable of personalizing learning so that each student receives an optimal learning experience. Deep learning is essential for fostering creativity, innovation, and competitiveness among the younger generation.

Implementation challenges, however, still persist from teacher readiness and unequal educational infrastructure to an evaluation culture that emphasizes exam results over learning processes. Nonetheless, if these challenges are addressed through strengthened teacher training, investment in educational technology, and assessment system reform, the deep learning curriculum can become a central pillar in achieving the Indonesia Emas 2045 roadmap.

Method

These challenges indicate the need for a paradigm shift in education from conventional models toward approaches that are more in-depth, reflective, and applicable. In the pedagogical context, deep learning is understood not merely as a term in artificial intelligence, but as a learning approach that emphasizes conceptual understanding, cross-disciplinary knowledge integration, and the development of higher-order thinking skills such as critical, creative, and problem-solving abilities (Biggs & Tang, 2011). This approach is believed to be a transformative strategy for preparing the golden generation expected to become the key driver in achieving the vision of Indonesia Emas 2045.

This study employs a qualitative approach using a conceptual library research method. This approach was chosen because the research aims to analyze and synthesize various concepts, theories, and previous studies related to educational transformation based on deep learning within the context of achieving the Indonesia Emas 2045 vision.

The data sources in this study are drawn from a wide range of scholarly literature, including books, indexed journal articles, government policy reports, and documents from international organizations such as UNESCO, the World Bank, and the OECD. The inclusion criteria focus on sources relevant to themes such as deep learning in education, strengthening 21st-century skills, literacy and numeracy development, and human resource policies. Meanwhile, non-academic literature, public opinion pieces, and non–peer-reviewed sources were excluded from the analysis.

 ISSN 2747-089X

The analysis process involved thematic categorization and synthesis. Each piece of literature was examined in depth to identify major themes such as the concept of deep learning, its integration with Higher Order Thinking Skills (HOTS), its relation to the demographic bonus, and its role in supporting the Indonesia Emas 2045 curriculum framework. Themes with similar meanings were grouped and synthesized to build a comprehensive understanding of how deep learning can serve as a transformative approach within the national education system.

Data analysis employed content analysis techniques, where significant information from the literature was examined, coded, and critically interpreted. This process included identifying key ideas, linking concepts, and drawing conceptual conclusions that demonstrate the interconnection between pedagogical theories, educational policies, and global challenges. The validity of the analysis was strengthened through cross-source comparison (triangulation) to ensure that the synthesized findings have a solid scientific foundation.

Through this approach, the study produces a conceptual framework illustrating how the application of deep learning in education can serve as a transformative strategy to enhance 21st-century competencies, improve literacy and numeracy, and support the roadmap toward Indonesia Emas 2045.

Result and Discussion

Table 1. Research Findings

Aspect Examined	Key Findings	Supporting Sources
Concept of Deep Learning in Education	Deep learning represents an educational paradigm emphasizing deep understanding, conceptual interconnection, and the application of knowledge in real-life contexts. It rejects rote memorization (surface learning) and fosters critical, reflective, and creative thinking.	Muvid (2024); Syi'bul Huda et al. (2025)
Global Development and Implementation of Deep Learning	Internationally, the discourse and implementation of *deep learning curriculum* have increased exponentially since 2020. Finland and Singapore have successfully integrated digital tools and artificial intelligence to promote adaptive, personalized, and sustainable learning systems.	Syi'bul Huda et al. (2025); Yusriati & Mardiati (2025)
Context of Indonesian Education	Indonesia's education system remains dominated by rote learning, with low literacy and numeracy outcomes. Deep learning is urgently needed to transform learning toward *mindful*, *meaningful*, and *joyful learning*—forming adaptive and value-driven learners.	Muvid (2024); Kemendikbudristek (2022)
Strengthening 21st-Century Competencies	Deep learning aligns with the framework of 21st-century skills—critical thinking, creativity, communication, and collaboration	Iriawan (2017); Suwandi et al. (2024)

 ISSN 2747-089X

Aspect Examined	Key Findings	Supporting Sources
	(4C)—through project-based, collaborative, and problem-based learning approaches.	
Integration of Technology and Artificial Intelligence (AI)	The incorporation of AI in deep learning enables personalized education through learning analytics, adaptive feedback, and intelligent content recommendations, fostering inclusivity and learning efficiency.	Turmuzi (2025a); Adnyana (2024)
Demographic Bonus and Transformative Education	Deep learning serves as a strategic framework for leveraging Indonesia's demographic bonus (2030–2045). It cultivates critical, creative, and digitally literate generations capable of driving innovation and productivity in a competitive global era.	Nuriman et al. (2025); World Bank (2020)
Deep Learning, HOTS, Literacy, and Numeracy	The integration of deep learning with Higher Order Thinking Skills (HOTS) enhances students' analytical, evaluative, and creative abilities. Collaborative and open-ended learning tasks significantly improve literacy and numeracy competencies.	Hafidzni et al. (2025); Hasdiana Hadjaratie et al. (2023)
Urgency of Deep Learning–Based Curriculum for Indonesia's Golden Vision 2045	A deep learning–based curriculum serves as a strategic instrument to strengthen the *Merdeka Curriculum*, improve literacy and numeracy, and develop globally competitive human resources for Indonesia's Golden Vision 2045.	Muvid (2024); Huda et al. (2025); Turmuzi (2025)
Challenges in Implementation	Major challenges include limited teacher readiness, unequal digital infrastructure, and exam-oriented assessment culture. These can be addressed through teacher capacity building, educational technology investment, and process-based evaluation reform.	Kemendikbudristek (2022); Turmuzi (2025a)

Findings from the literature analysis indicate that the transformation of education through deep learning constitutes both a conceptual and strategic foundation for realizing the *Indonesia Emas 2045* vision. This concept is not merely understood as a pedagogical approach but as a new educational paradigm that synergistically integrates cognitive, affective, and technological dimensions. Such transformation demands a fundamental shift from *surface learning* which emphasizes rote memorization and information reproduction toward *deep learning*, which emphasizes the construction of meaning, deep conceptual understanding, and the application of knowledge in real-life contexts (Muvid, 2024). Consequently, deep learning

 ISSN 2747-089X

functions as a catalyst that strengthens reasoning ability, critical reflection, and creativity among learners, equipping them to navigate the complexities of the twenty-first century.

Since 2020, international discourse on *deep learning curriculum* has shown exponential growth (Syi'bul Huda et al., 2025a). This trend has been driven by the global demand for learning models that are adaptive to technological advancement and socio-economic change. Countries such as Finland and Singapore serve as concrete examples of how *deep learning* has been integrated into national education policies. Finland places innovation and sustainability at the core of its curriculum by utilizing *digital tools* and online learning platforms that promote flexibility and personalization in learning (Yusriati & Mardiati, 2025). Similarly, Singapore's *Smart Nation Initiative* integrates *big data* and artificial intelligence into the education system to map student learning profiles, optimize assessments, and strengthen digital competencies. Empirical evidence from these countries reveals that integrating *deep learning* with technology enhances student engagement, academic achievement, and readiness for a technology-driven workforce.

In the Indonesian context, *deep learning* emerges as an urgent necessity rather than a pedagogical choice. The nation's educational weaknesses—such as low literacy and numeracy achievement, uneven teacher quality, and the persistence of rote-based learning methods underscore the need for curricular transformation. Within this framework, *deep learning* offers an approach that fosters reflective awareness (*mindful learning*), contextual understanding (*meaningful learning*), and intrinsic motivation to learn (*joyful learning*) (Diputera et al., 2024). These three pillars are not merely instructional strategies but philosophical orientations that shape future generations into adaptive, collaborative, and creative individuals. This approach aligns with the mission of nurturing a *Golden Generation* endowed with global competitiveness, emotional intelligence, and critical thinking skills.

The connection between *deep learning* and the reinforcement of twenty-first-century competencies has become increasingly significant. Education in the twenty-first century is no longer confined to the transfer of knowledge but focuses on developing cognitive and social competencies, including *critical thinking, creativity, communication,* and *collaboration* (Iriawan & Indonesia, 2017). In this regard, *deep learning* serves as an approach that integrates cross-disciplinary projects, collaborative discussions, and *problem-based learning*, training students to engage in higher-order thinking and solve real-world problems (Suwandi et al., 2024). Supported by artificial intelligence (Turmuzi, 2025), learning systems can personalize content, provide adaptive feedback, and promote learner autonomy. This transformation marks a paradigm shift from traditional instructional models toward intelligent, data-driven, and personalized learning ecosystems.

From a demographic perspective, *deep learning* also holds strategic value in leveraging Indonesia's demographic bonus between 2030 and 2045. As the proportion of the productive-age population reaches its peak, the quality of human capital will determine the nation's developmental trajectory (Nuriman et al., 2025). In this context, *deep learning* plays a crucial role in cultivating a productive generation that is not only job-ready but also capable of creating employment opportunities. By fostering critical thinking, digital literacy, and creativity, this approach ensures that the population surge becomes a productive *demographic dividend* rather than a *demographic burden*. This is consistent with the World Bank's (Bank, 2020) warning that educational success should not be measured solely by school participation rates but by meaningful *learning outcomes*.

Further findings highlight that integrating *deep learning* with *Higher Order Thinking Skills (HOTS)* directly contributes to improving literacy and numeracy performance. Hafidzni et al. (2025) demonstrate that students engaged in *deep learning*-based instruction show significant improvement in analytical, evaluative, and creative problem-solving abilities. This is reinforced by Hasdiana Hadjaratie et al. (2023), who emphasize creativity as a key competency in facing global disruption. By emphasizing collaborative projects and open-ended exploration, *deep learning* not only deepens conceptual understanding but also cultivates an innovative mindset essential for

 ISSN 2747-089X

success in the digital age. Adnyana (2024) further introduces a technological dimension to *deep learning*, highlighting the role of AI-based tutors and intelligent learning recommendations in making education more inclusive and responsive to diverse learning styles.

Conceptually, a *deep learning*-based curriculum serves as a bridge toward the *Indonesia Emas 2045 Roadmap*. Muvid (2024) asserts that this approach represents an extension of constructivism that strengthens the core principles of the *Merdeka Curriculum*—namely, meaningful and contextualized freedom to learn. Huda et al. (2025) further explain that global educational trends are moving toward evolutionary curricula that integrate *emerging technologies* and promote advanced vocational preparedness. Thus, *deep learning* is not only academically relevant but also strategically aligned with national policy priorities in producing high-quality human capital capable of competing at the global level.

Nevertheless, significant implementation challenges remain. Limited teacher training, disparities in digital infrastructure, and an assessment culture overly focused on test outcomes pose major obstacles. However, these challenges can be addressed through collaborative strategies involving teacher capacity-building, investment in educational technology, and assessment reform that values process over product. With visionary policymaking and an adaptive educational ecosystem, *deep learning* has the potential to serve as both the epistemological foundation and practical instrument for constructing a transformative education system that propels Indonesia toward the realization of its *2045 Golden Vision*.

Conclusion

The implementation of education based on deep learning serves as a crucial strategy within the Indonesia Emas 2045 roadmap. This approach effectively addresses the persistent challenges of low literacy, numeracy, and 21st-century skill attainment that continue to hinder Indonesia's education system. *Deep learning* encourages students to think critically, creatively, and collaboratively, while applying their knowledge in real-world contexts making it highly relevant to global demands and the demographic bonus expected between 2030 and 2045.

Nevertheless, the implementation of *deep learning* faces serious obstacles, such as the limited readiness of teachers, unequal distribution of educational infrastructure, and an assessment culture overly focused on exam results. Therefore, strategic commitments are required through comprehensive teacher training, investment in educational technology, and reform of the assessment system. With these measures, a *deep learning*-based curriculum has the potential to become a central pillar of educational transformation shaping high-quality, innovative, and globally competitive human resources that will drive Indonesia toward the realization of Indonesia Emas 2045**.**

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