Can Deep Learning Provide Solutions to The Challenges of 21st-Century Education in Indonesia?

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Abstract:

The focus of this article is the potential of deep learning as a solution to overcome the challenges of 21st-century education in Indonesia, particularly in developing critical thinking skills, creativity, communication, and collaboration. The main question discussed is how deep learning can be effectively implemented in the national education system by addressing infrastructure challenges, teachers' digital literacy, and unequal access to education. This study employs a qualitative approach using the library research method. The data consist of secondary sources such as books, scientific journals, policy reports, and relevant official documents. The findings indicate that deep learning holds great potential for improving the quality of education in Indonesia, despite facing challenges such as limited infrastructure, teacher readiness, and insufficiently supportive education policies. The article recommends strategies including continuous teacher training, equitable distribution of technological infrastructure, and the development of contextual education policies as essential steps to maximize the application of deep learning in achieving the Golden Indonesia 2045 vision.

1. Introduction

21st-century education presents new challenges that demand innovative approaches to equip students with relevant competencies. Critical thinking, creativity, communication, and collaboration are central to students' success in navigating the complexities of the modern world. In this context, a learning approach based on deep learning has emerged as a promising solution. A study by [2] showed that the application of learning based on deep understanding can improve students' ability to think critically and solve complex problems [2]

Deep learning in education refers to a learning approach that emphasizes in-depth understanding, critical analysis, and the practical application of concepts to real-life situations. Unlike traditional learning, which often prioritizes memorization and repetition, deep learning actively engages students in the learning process, fostering a stronger connection between theoretical knowledge and practical implementation. Research by (Jones, Smith, & Taylor, 2022) [15] also affirmed that *deep learning* enable students to understand topics holistically, which are in-depth and relevant to their

daily lives [16]. (Hattie, 2009) It also emphasizes the importance of student feedback and engagement in learning, two elements that are at the core of the deep learning approach [12].

In Indonesia, the national education policy issued by the Ministry of Primary and Secondary Education (Kemendikdasmen) emphasizes the importance of a student-centered learning approach. The implementation of the Independent Curriculum represents a concrete step toward supporting in-depth, competency-based learning. This curriculum is designed to provide educators with the flexibility to design relevant, contextual, and project-based learning experiences, aligning with the principles of deep learning. According to a report by the Ministry of Education and Culture, more than 25% of schools in Indonesia had adopted the Independent Curriculum by 2024, enabling greater flexibility in the implementation of competency-based learning (Ministry of Education and Culture, 2024).

Recently, the Minister of Primary and Secondary Education and Culture, Abdul Mu'ti, introduced the concept of "*Deep Learning Ful-Ful*which emphasizes three main principles: Mindful,

Meaningful, and Joyful. *Mindful Learning* Invite students to be actively and consciously involved in the learning process, encouraging them to think critically and reflectively. *Meaningful Learning* ensuring that each learning has a clear purpose and relevance to students' real lives, so they can see the meaning of what they are learning. *Joyful Learning* creating a fun and motivating learning atmosphere, with the aim of making the learning process more effective and enjoyable. A study of (Universitas Pendidikan Indonesia, 2023) indicates that the application of *Joyful Learning* in some elementary schools, it has increased students' interest in learning by 30% compared to conventional methods [32]. Other research by (Ministry of Education, Malaysia, 2020) shows that fun-based learning also increases students' endurance in completing complex tasks (Ministry of Education, Malaysia, 2020).

However, the implementation of this policy continues to face several challenges, including teacher readiness, alignment of the curriculum with local needs, and the availability of adequate educational infrastructure. Moreover, disparities between schools in urban and rural areas further complicate the adoption of this approach. Based on data from (Central Statistics Agency, 2023), about 45% of schools in rural areas still face major challenges in accessing technology and training for the implementation of in-depth competency-based curricula (Central Statistics Agency, 2023). This challenge is further exacerbated by the low digital literacy among teachers, as expressed by [31], which shows that only 40% of teachers in Indonesia feel confident enough to use technology in learning. Research by [20] revealed that the implementation of flexible education policies in rural areas is still disrupted by the low availability of technological tools and professional training for teachers. This causes inequality in the application of learning approaches based on deep learning, which urgently needs adequate technological support [20]. In addition, a World Bank report (2023) highlights that 35% of students in remote areas of Indonesia still have limited access to relevant and contextual teaching materials.

The main problem that arises is the existence of a significant gap in implementation *deep learning* in various regions in Indonesia. Limited infrastructure, lack of professional training for teachers, and low digital literacy are obstacles that hinder the equitable distribution of learning quality [21]. In fact, deep learning has great potential to develop students' critical and creative thinking skills, which are urgently needed to prepare for the golden generation of 2045. Therefore, it is crucial to conduct further studies on the effectiveness and challenges of implementing deep learning within the context of Indonesian education. This article explores how this approach can be practically integrated into Indonesia's diverse education system and examines how policies can be adapted to align with local needs and existing infrastructure conditions. Research from [14] underlining the importance of understanding the local context in the implementation of educational innovation, so that the strategies implemented can be more effective and relevant [14]. This article is expected to make the right contribution to maximize the potential of *deep learning* in improving the quality of learning and preparing Indonesian students to become the golden generation of 2045.

2. Research Methods

The research method in this article uses a qualitative approach with the literature method (*Library Research*) [23]. This method was chosen to explore in depth the theories, policies, and studies relevant to the implementation of deep learning-based learning in the context of education in Indonesia. The data used is in the form of secondary sources, such as books, scientific journals, policy reports, and official documents from the government and educational institutions [28]. This approach allows authors to conduct critical analysis of various theoretical views and existing empirical evidence, so as to produce a comprehensive synthesis of the challenges and opportunities of deep learning applications. By reviewing the existing literature, this article also aims to identify research gaps and provide data-driven recommendations to support the implementation of more effective education policies. In addition, literature analysis also provides space to compare Indonesia's experience with best practices from other countries, which can be a reference in overcoming local barriers.

3. Results And Discussion

3.1 Concepts and Principles of Deep Learning in Education

Term *deep learning* In the world of education, it refers to a learning process that involves a deep understanding of subject matter, not just memorization or superficial understanding. *Deep learning* prioritizing the active involvement of students in the learning process so that they are able to relate the knowledge learned to real-world experiences, resulting in a stronger and more durable understanding [7]. The concept includes

three main elements: *Mindful Learning*, *meaningful learning* and *Joyful Learning*.

Mindful learning focuses on full awareness in the learning process, where students not only receive information, but are also actively involved in processing and reflecting on that knowledge. *Meaningful learning* refers to learning that is relevant to students' lives, which allows them to see the connection between theory and practice. Meanwhile, *joyful learning* emphasizes the importance of the element of happiness and motivation in learning, so that students feel enthusiastic and encouraged to continue learning.

Hattie, (2009), in his book *Visible Learning*, emphasizing the importance of student feedback and engagement in learning [12]. Hattie argues that one of the most significant factors that can affect a student's academic achievement is their level of involvement in the learning process. Effective feedback, both from teachers and peers, can speed up understanding and correct deficiencies in student comprehension. By providing constructive feedback, students can evaluate and correct their understanding, ultimately helping them to reach the *deep learning*. In addition, student involvement in setting learning goals and reflection on the learning process is also very important, as it encourages students to feel in control of their own learning.

Application *deep learning* in education not only relies on major theories as described by Hattie, but is also supported by various empirical studies. One of the relevant studies is the one conducted by [2], which indicates that *deep learning* has a positive impact on students' critical thinking skills. In their research, Ainsworth and Tharp found that students who engage in deep learning tend to be better able to analyze information, identify problems, and formulate creative solutions. This shows that *deep learning* not only improves material comprehension, but also develops more complex cognitive skills, such as analytical and reflective thinking.

Another study that supports these findings is the one conducted by [14], which indicates that the application of *deep learning* can improve students' critical thinking skills. In the study, Jones and his colleagues observed the impact of learning involving *mindful, meaningful* and *Joyful Learning* on students' critical thinking skills. The results of this study show that students who are involved in meaningful and conscious learning are more able to assess and evaluate information in a more reflective and analytical way. This kind of learning not only focuses on understanding concepts, but also on developing deeper thinking skills, which are crucial in facing the challenges of the 21st century. Integrating deep learning into daily educational practices requires a shift in teaching approaches. Teachers must create an environment that encourages students to actively engage in learning and motivates them to continue exploring new ideas. This entails developing teaching strategies that focus not only on mastery of the material but also on the development of students' critical and reflective thinking skills [13]. One effective way to achieve this is through a project-based learning approach, which enables students to learn through real-life experiences and address problems relevant to their lives.

In addition, the application of deep learning also requires support from schools and parents. Schools must provide adequate resources, such as learning spaces that foster collaboration and technology that enriches the learning process. Parents also play a crucial role in creating a supportive deep learning environment outside of school, by guiding their children in developing curiosity and providing opportunities to connect learning with everyday life [19].

However, the main challenge in implementing deep learning is overcoming resistance to changes in the existing education system. Many schools and teachers remain entrenched in traditional learning practices that emphasize informational and exam-based teaching. Therefore, educators must continuously update their understanding of the importance of deep learning and seek ways to integrate it into existing curricula.

Important *deep learning* It is also seen in the context of education for the future. In an increasingly complex and rapidly changing world, students need to be equipped with skills that allow them to think critically, creatively, and adaptively. Deep learning not only helps students to understand the material more thoroughly, but it also gives them the ability to face challenges they may face in the real world (Afista et al., 2020). With strong critical thinking skills, students can more easily adapt to change and make better decisions.

Application of the concept *deep learning* In education, it is not only important to improve students' academic achievement, but also to prepare them for the global challenges of the future. This concept teaches us that meaningful, conscious, and fun learning can develop critical thinking skills that are needed in everyday life (Mahendra & Yuliawati, 2023). Along with technological developments and changes in the world of work, deep learning is becoming increasingly relevant and must be integrated into our education system. Therefore, it is important for educators, policymakers, and other stakeholders to work together in creating an educational environment

that supports the implementation of *deep learning* for all students.

3.2 Implementation of Deep Learning in National Education Policy

Implementation *deep learning* in Indonesia's national education policy has been a major concern in recent times, in line with efforts to achieve the vision of Golden Indonesia 2045. A deep learning approach that focuses on meaningful, reflective, and in-depth learning, in line with the latest education policies such as the Independent Curriculum (Hamidah, 2022). The Independent Curriculum provides flexibility in teaching, allowing students to learn in a more independent, exploratory, and project-based way, which strongly supports the principles of deep learning.

Application *deep learning* in Indonesia in line with fundamental changes in education policy that emphasize the development of 21st century skills, such as critical thinking skills, creativity, and problem-solving. Research conducted by (Hidayani, 2023) shows that the Independent Curriculum opens opportunities for educators to apply more innovative methods, including deep learning. Thus, the Indonesian education system not only focuses on mastering the material, but also on improving students' competence in applying knowledge in real situations [13].

In the context of broader education policies, the Indonesian government also emphasizes the importance of integrating technology in learning. Technology, especially artificial intelligence (AI) and digital learning, is an important element in supporting the implementation of deep learning. As discussed by (T. Kurniawan & Prasetyo, 2024), technology can enrich students' learning experience, allowing them to learn in a more personalized way, with prompt and relevant feedback [21]. Therefore, policies that support the development of technological infrastructure are crucial in integrating deep learning into the education system.

However, the main challenges in implementation *deep learning* is the gap in access to technology between urban and rural areas. (Suharyo, 2023) revealed that many schools in remote areas still have difficulty accessing adequate educational technology. Therefore, education policies must ensure equitable access to technology and educational resources throughout Indonesia, so that the benefits of *deep learning* can be felt by all students.

Deep learning It also emphasizes the importance of a more holistic and sustainable evaluation. Assessment in this approach is not only based on exams or tests, but also includes the development of practical skills, critical thinking skills, and creativity of students. (Jones, Smith, & Brown, 2022) Explain that project-based assessment and constructive feedback are effective methods to support deep and meaningful learning. Therefore, national education policies need to develop assessment systems that support this approach.

In addition, the successful implementation of the *deep learning* Education policy also relies heavily on teachers' ability to adapt more active and experiential learning methods. Teacher training is an important aspect in ensuring that they can effectively integrate deep learning in the classroom. As explained by (Arifin, 2023), continuous training for teachers in the use of deep learning-based technology and learning methodologies is urgently needed to support the success of this policy.

The involvement of parents and the community is also an important factor in the successful implementation of deep learning. (Sulastri & Suwandi, 2024) suggested that collaboration between schools, parents, and communities is essential to create an environment that supports deep learning. Parents who are involved in their children's education can help reinforce concepts learned in school and encourage students to be more active in exploring new ideas.

The application of *deep learning* can also play a role in strengthening character education. With a more experiential and reflection-based approach, students are expected to not only master academic knowledge, but also develop values such as a sense of responsibility, honesty, and leadership. This is in accordance with the basic principles of education in Indonesia which not only prioritizes cognitive aspects, but also affective and psychomotor aspects.

In implementation *deep learning*, schools need to adopt a more flexible and student-needs-based approach. Research by (Wulandari, 2024) It shows that learning models involving deep learning-based projects provide opportunities for students to interact with the real world, solve complex problems, and apply the knowledge gained in more relevant contexts. Therefore, national education policies must provide space for schools to design curricula and learning activities that are more contextual and relevant to the needs of the world of work.

National education policy also needs to pay attention to the inclusivity aspect in the implementation of deep learning. All students, including those with special needs, should be given an equal opportunity to benefit from this approach. As suggested by [31], inclusive education allows all students to develop according to their abilities and potential, without leaving anyone behind. This is a

challenge in the implementation of deep learning, but it is very important to ensure equality in education.

Overall, *deep learning* offers great potential to improve the quality of education in Indonesia. Through the implementation of policies that support the application of technology, adequate teacher training, and the development of an experience- and project-based curriculum, it is hoped that the next generation of Indonesia can face global challenges with more comprehensive and in-depth skills.

3.3 Challenges in Deep Learning Implementation in Indonesia

As explained at the beginning of the discussion, deep learning offers a more in-depth and student-centered approach to learning and has great potential to transform Indonesian education. However, like other innovations, the implementation of deep learning in Indonesia faces various challenges. Despite its significant potential, several obstacles must be addressed to achieve better education, particularly in terms of infrastructure, teacher competence, and unequal access to education in certain areas.

The limitations of infrastructure and technology in many regions, especially in remote areas, are a big challenge in implementing *deep learning*. Based on data from the Central Statistics Agency [5], about 45% of schools in rural areas still struggle to access adequate technology. Many schools lack computer equipment, and many have problems with slow or even no internet connections.

Whereas *deep learning* rely heavily on digital technology. Without access to adequate devices and a stable internet network, learning is based on *deep learning* become almost impossible to implement effectively. In this condition, technology is not only a tool, but also a link between teachers and students, as well as a means to access various innovative learning resources. Unfortunately, without adequate infrastructure support, students in certain areas will find it more difficult to enjoy a rich and well-rounded learning experience [36].

In addition to infrastructure problems, the low digital literacy among teachers is also a big challenge. Data from [31]shows that only about 40% of teachers feel confident in using technology in learning. This reflects that many teachers still find it difficult to integrate technology in their teaching and learning process.

Low digital literacy prevents teachers from making good use of technology, even though this technology is very important for deep learning-based learning [27]. Without adequate knowledge

of how to use digital devices and applications, teachers will struggle to create an immersive and enjoyable learning experience for students. Therefore, it is important to provide continuous training for teachers, so that they are better prepared to face the demands of the times and can optimally integrate technology in the classroom [26].

The issue of inequality in access to education significantly impacts the implementation of deep learning. In remote areas, access to relevant educational technology and resources remains very limited [24]. Many schools still lack teaching materials that support technology-based learning, and digital devices, such as laptops or tablets, are rarely available.

In contrast, schools in larger cities or more economically developed areas have better access to technology and learning resources. This inequality creates a gap in the quality of education [3]. Students in urban areas may benefit from a richer and more interactive learning experience, while students in remote areas are often limited to more traditional and less dynamic learning methods. To ensure that deep learning is implemented equitably, efforts must be made to bridge this gap.

To overcome the challenges of digital literacy, training and developing teachers' digital competencies is a very important step. One solution is to provide structured training that not only teaches how to use digital devices, but also how to integrate them in deep learning methodologies. Through this training, it is hoped that teachers can design a more interactive and fun learning experience for students, as well as encourage them to think critically and creatively (Hidayani, 2023) [13].

Improving teachers' digital competencies will also help create a more dynamic classroom atmosphere [13]. When teachers feel more confident in using technology, it will be easier for them to implement more innovative and immersive learning methods, such as deep learning, that prioritize meaningful learning experiences for students.

Another challenge that is no less important is financial problems. To implement deep learning effectively, significant investment is needed in terms of procurement of technology devices, teacher training, and development of technology-based curriculum [8]. Schools in budget-constrained areas often struggle to provide the necessary equipment or allocate funds for teacher training.

Therefore, it is important for the government to increase the allocation of education budgets, especially for underdeveloped areas, so that they can also feel the benefits of technology in

education. This investment is critical to ensuring that all students, without exception, have access to the same learning experience.

Given the considerable challenges, collaboration between the government, the private sector, and the community is very important. The government should encourage the improvement of educational infrastructure and provide training for teachers [11]. The private sector can play a role by providing tools and applications that support technology-based learning. Meanwhile, the community can also play a role in providing support to underprivileged schools, for example by donating equipment or holding training.

This solid collaboration will accelerate the distribution of technology and training throughout Indonesia, ensuring that no student is left behind in accessing quality education based on deep learning. With a more collaborative approach and a focus on improving infrastructure, digital literacy, and equitable access, Indonesia can realize a more inclusive and quality education. Technology, if applied correctly, can have an extraordinary positive impact on the learning process and the development of students throughout the archipelago.

3.4 Strategies to Improve Deep Learning Implementation

Deep learning in education is becoming an increasingly relevant approach along with the changes that occur in the way we understand meaningful and deep learning. Strategies to improve the implementation of deep learning in education depend on several key factors, one of which is continuous teacher training. This training aims to improve digital literacy and teachers' professional competence in implementing a more in-depth learning approach and actively involving students. Effective teacher training must integrate the development of critical thinking skills, reflection, and a deep understanding of the learning material being taught. In this context, the theory of constructivism put forward by Piaget and Vygotsky becomes very relevant [33]. Piaget considers learning to be an active process in which students build their knowledge based on experience, while Vygotsky emphasizes the importance of social interaction in learning. Therefore, teachers must have the skills to create an environment that supports active learning, which is in line with the principles of deep learning [33].

(Hattie, 2009) in his book *Visible Learning* It also explains the importance of effective feedback in improving learning outcomes. Teacher training should include techniques for providing constructive feedback as well as how to involve students in their self-evaluation [12]. This is in line with the idea that students need to be empowered to be active participants in their learning process, not just as recipients of information. Teachers need to be provided with training on how to design learning activities that not only encourage students to process information in depth, but also to develop reflective skills necessary in deep learning-based learning.

In addition to teacher training, the procurement of adequate infrastructure is also an important element in supporting the implementation of deep learning. Access to the right technology is crucial, especially in the context of learning that relies on the use of various digital tools to explore the subject matter. However, the big challenge faced is the unequal access to technology in various regions. As stated by [2]success *deep learning* highly dependent on the availability of appropriate technology. The theory of diffusion of innovation put forward by (Gideon, 1968) explained that technology adoption is not only influenced by individual readiness, but also by social and economic factors [19]. Therefore, equitable access to technology, especially in underdeveloped areas, is essential to ensure that all students, regardless of their geographical location, can benefit from the deep learning approach.

This equal distribution of access is not only limited to hardware such as computers and tablets, but also to stable and fast internet access. Without adequate infrastructure, the use of technology for deep learning-based learning is limited. By ensuring that every school, whether in a city or in a remote area, has adequate technological facilities, we can create an equal opportunity for all students to engage in deep learning-based learning. This is also in line with the theory of constructivism which considers technology as a tool that can enrich students' learning experience if used appropriately.

However, not only technological infrastructure needs to be considered, but also education policies that are in accordance with local needs. According to [14], education policies must be contextualized with local needs and characteristics. Policies that are tailored to the local context will be more effective in creating a learning environment that supports the application of deep learning. Educational ecological theory developed by [6] emphasizes the importance of understanding the education system as part of a larger social system, where external factors such as culture, economy, and technology play a crucial role in shaping the student learning experience. Therefore, education policies must pay attention to local conditions, including the availability of resources, community culture, and access to technology.

For example, in areas with limited access to technology, education policies can be directed to develop learning models that do not depend entirely on internet connections, such as the use of offline learning media or mobile devices that can be accessed without the need for a stable internet connection. In addition, the policy can encourage community-based learning, where students are invited to apply their learning in a local context, by utilizing local natural resources or culture. Thus, deep learning not only develops students' cognitive abilities, but also connects them to their social and cultural environment.

The contextualization of this policy is also in line with the principles of project-based learning and collaboration that are at the core of deep learning. Dewey (1938) as quoted by (Wijayanto, 2021) argues that education should connect students' learning experiences with their daily lives. Project-based learning, which allows students to solve real problems through collaboration, is one way to encourage student engagement in deeper learning [34]. Through project-based learning, students not only master knowledge, but also develop critical and creative thinking skills that are critical in an ever-changing global context.

In this case, evaluation and feedback are also an integral part of the deep learning process. [2] emphasizing that effective feedback can accelerate the improvement of student learning outcomes. In the context of deep learning, evaluation should not only measure how much knowledge students have, but also how students can connect and apply that knowledge in a broader context. This deep understanding-based evaluation encourages students to think critically and reflectively, which is the main goal of deep learning itself. Therefore, teachers need to be trained to provide in-depth and constructive feedback, which helps students to improve their understanding on an ongoing basis.

In addition, collaboration between various parties is also a very important factor in the implementation of *deep learning*. As explained by Vygotsky in his theory of social constructivism, social interaction in the learning process can enrich students' understanding [25]. Therefore, it is important for teachers, students, parents, and the community to work together in creating an immersive learning environment. Parents, as educational partners, have an important role to play in supporting students to develop critical and reflective thinking skills outside of school hours. Policies that involve parents in the learning process can strengthen the implementation of deep learning, as they can help students in processing and understanding the knowledge they learn.

Finally, the implementation of *deep learning* in education must always be updated and adjusted to the times. Along with the rapid advancement of technology, education must be able to adapt and use technology effectively to improve the quality of learning. Therefore, the development of a more flexible curriculum based on 21st century skills is essential to support the application of deep learning in education. With the right integration of technology, continuous teacher training, as well as education policies that are relevant to local needs, we can ensure that deep learning can be applied effectively to produce students who not only master knowledge, but are also able to think critically, creatively, and are ready to face global challenges.

The implementation of deep learning in education requires collaboration between various parties, ranging from teachers, students, parents, to the government. For this reason, it is necessary to pay serious attention to teacher training, equitable distribution of technological infrastructure, and policy adjustments in accordance with local needs. With the right strategy, deep learning can be the key to improving the quality of education in Indonesia, developing critical thinking skills, and preparing students to face the challenges of a changing world.

4. CONCLUSION

The application of *deep learning* offers great potential in improving the quality of Indonesian education through meaningful, reflective, and in-depth learning. While challenges such as infrastructure limitations, low digital literacy, and inequalities in access remain, this approach is in line with the vision of 21st century education. With the right strategies and collaboration between various parties, *deep learning* can be the key to improving the quality of education and preparing students for global challenges.

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