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TRANSFORMING SCIENCE LEARNING WITH DIGITAL-BASED DEEP LEARNING FOR JUNIOR HIGH SCHOOL STUDENTS

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ABSTRACT

This study aims to examine the application of deep learning technology in the learning process at junior high schools (SMP) in Konawe Regency. Deep learning, as a branch of artificial intelligence (AI), has the potential to improve learning effectiveness through personalisation of teaching materials and comprehensive data analysis of student development. The research objects include four junior high schools in Konawe Regency, namely SMPN 1 Unaaha, SMPN 2 Unaaha, SMPN 1 Wonggeduku, and SMPN 2 Wonggeduku. The method used is a case study with a qualitative approach, which includes interviews with teachers and principals as well as direct observation of the implementation of deep learning in the learning process. The results show that although the implementation of deep learning technology is still on a limited scale, its impact on improving the quality of learning including increased student motivation, better understanding of the material, and more precise ability to analyse student development is quite significant. However, the implementation of this technology still faces a number of obstacles, especially related to infrastructure limitations and the need for continuous training for teachers. Therefore, this study recommends increasing infrastructure support and continuous training so that the potential of deep learning can be maximised in the context of secondary education.
Keywords: *Deep Learning, Science Learning, Digital*

ABSTRAK

Penelitian ini bertujuan untuk mengkaji penerapan teknologi pembelajaran mendalam (deep learning) dalam proses pembelajaran di Sekolah Menengah Pertama (SMP) di Kabupaten Konawe. Pembelajaran mendalam, sebagai salah satu cabang kecerdasan buatan (AI), berpotensi meningkatkan efektivitas pembelajaran melalui personalisasi materi ajar dan analisis data perkembangan siswa yang komprehensif. Objek penelitian meliputi empat SMP di Kabupaten Konawe, yaitu SMPN 1 Unaaha, SMPN 2 Unaaha, SMPN 1 Wonggeduku, dan SMPN 2 Wonggeduku. Metode yang digunakan adalah studi kasus dengan pendekatan kualitatif, yang meliputi wawancara dengan guru dan kepala sekolah serta observasi langsung terhadap implementasi pembelajaran mendalam dalam proses pembelajaran. Hasil penelitian menunjukkan bahwa meskipun implementasi teknologi pembelajaran mendalam masih dalam skala terbatas, dampaknya terhadap peningkatan kualitas pembelajaran, termasuk peningkatan motivasi siswa, pemahaman materi yang lebih baik, dan kemampuan menganalisis perkembangan siswa yang lebih presisi, cukup signifikan. Namun, implementasi teknologi ini masih menghadapi sejumlah kendala, terutama terkait keterbatasan infrastruktur dan perlunya pelatihan berkelanjutan bagi guru. Oleh karena itu, studi ini merekomendasikan peningkatan dukungan infrastruktur dan pelatihan berkelanjutan agar potensi pembelajaran mendalam dapat dimaksimalkan dalam konteks pendidikan menengah.
Kata Kunci: *Pembelajaran Mendalam, Pembelajaran Sains, Digital*

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INTRODUCTION

Advances in information and communication technology (ICT) in recent decades have had a significant impact on education (Jia et al., 2025) . The application of technology, especially artificial intelligence (AI)-based, is expanding to improve learning effectiveness. Deep learning, one of the branches of AI, shows great potential in data processing, supporting decision making, and improving the quality of learning (García et al., 2017) . Deep learning, according to (Lee et al., 2025) , is one of the most important and innovative approaches in the field of artificial intelligence. This approach focuses on learning data representations through multi-layered artificial neural network structures, also known as multilayer perceptrons (Qiu & Ishak, 2025) . By using this complex architecture, deep learning is able to recognise patterns and features from data with a high degree of accuracy, making it highly effective in various applications, such as image recognition, natural language processing, and speech recognition (Rjoop et al., 2025) .

In education, deep learning provides opportunities to optimise the learning process through in-depth data analysis, personalisation of teaching materials according to individual student needs, and increased accuracy in data-driven learning evaluation and assessment (Vaart et al., 2024) . Although deep learning technology has been widely implemented in higher education, its application in secondary and tertiary education is still relatively new and in the development and exploration stage (Puertas, 2025) . A number of educational institutions are beginning to realise the significant potential offered by this technology in supporting the improvement of learning quality and student understanding (Nelvia, 2019) . Through the use of machine learning algorithms and sophisticated data analysis techniques, educators have the opportunity to design learning experiences that are personalised and adaptive, so that learning materials can be tailored to the characteristics, needs and abilities of each learner (Saripudin et al., 2023) .

In Indonesia, the use of this technology at the junior high school (SMP) level is still relatively minimal in terms of research, especially in areas such as Konawe District which faces various challenges related to educational infrastructure and limited human resources. These factors have the potential to become obstacles in the process of adopting cutting-edge technology, including the application of deep learning in the context of education. The implementation of deep learning in the context of secondary education offers various advantages that contribute to improving the quality of learning, including through personalisation of learning materials, automated evaluation processes, and direct and continuous monitoring of student progress (Widiana et al., 2021) . By utilising this technology, educators can access more precise data related to students' learning progress, thus enabling faster and more relevant feedback to the individual needs of learners (Baneș et al., 2024) . In addition, the system supports learning approaches that are tailored to each student's learning pace, allowing them to learn without the pressure of a learning rhythm that is not suited to their abilities (Yang, 2024) .

One area in education that requires special attention is the learning of Natural Sciences (IPA) at the secondary school level. This subject has its own significance and attraction to be explored in more depth. Science learning is not only limited to understanding scientific theories and concepts, but also includes practical applications that are directly related to everyday life (Rabinowitz et al., 2025) . Through understanding the basic principles of science, students can more easily recognise various natural phenomena around them and understand the role of science in explaining events that occur in the world (Zavala-cerna et al., 2025) . Moreover, science learning encourages the development of critical and analytical thinking skills (Csaba et al., 2025) . Students are trained to carry out experiments, collect data, and draw conclusions

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based on observations, which are important steps in forming scientific thinking skills that are relevant to various aspects of life (Chmielewski et al., 2025) . In the context of rapid technological development, an understanding of science is becoming increasingly important, especially in dealing with global issues such as climate change, public health, and environmental sustainability (Bhandari et al., 2025) . In addition, science learning can also be an inspirational tool for students to pursue careers in science, technology, engineering and mathematics (STEM) (Kumala et al., 2022) .

In the context of science learning, the characteristics of students at the secondary school level today pose significant challenges for educators (Chmielewski et al., 2025) . One-way, text-focused, rote learning approaches to science learning have proven ineffective in meeting the learning needs of today's students (Kisworo et al., 2022) . However, many science teachers still rely on conventional methods such as lectures and memorisation, which are often monotonous, less interesting, and irrelevant to everyday life (Khamidah & Ita Sholichah, 2022) . This situation contributes to the decline in student interest and motivation in learning science subjects, even giving rise to the perception that this lesson is classified as difficult to understand. As an effort to overcome these problems, the use of digital learning media is seen as a strategic solution to increase students' interest in learning science subjects. The use of digital media, such as interactive applications, educational videos, and scientific simulations, allows the delivery of material in a more interesting and visual way, so that the learning process becomes more dynamic (Sunarti et al., 2023) . Visualisation of science concepts through animations or videos, for example, can bring scientific narratives to life and facilitate students' understanding, as well as increase their interest and attraction to this subject (Communication et al., 2024) .

In November 2024, Prof Abdul Mu'ti, Minister of Secondary Education, introduced this approach as part of a new direction in Indonesian education policy. In his statement, Prof Mu'ti emphasised that deep learning is not intended as a new curriculum, but rather as a learning method that has different characteristics from the previously implemented Merdeka Curriculum. In the realm of education, deep learning refers to efforts to provide comprehensive learning experiences and build learning environments that support deeper understanding, strengthen advanced thinking skills, and apply knowledge effectively and apply knowledge in various real situations (Wollmann & Lange-Schubert, 2022) . In line with this, as mentioned earlier, Deep Learning integrates the principles of *conscious, meaningful and enjoyable* learning. As with any government policy, the implementation of deep learning requires support from an ecosystem consisting of various elements that interact synergistically (Chai et al., 2011) . The education ecosystem provides a comprehensive framework of the relationship between stakeholders in order to ensure the implementation of deep learning policies runs optimally. One of the key elements in this ecosystem is the presence of teachers, who play an important role in implementing deep learning approaches effectively (Hastomo et al., 2024) . The strategic role of teachers in the ecosystem is explained as follows.

Figure 1: The Changing Role of the Teacher in the Deep Learning Ecosystem

Therefore, it is necessary to transform the role of teachers, especially in the aspect of leadership, which reflects the inverted pyramid pattern (Riastini et al., 2025) . In the context of implementing deep learning, teachers act as drivers, shapers of learning culture, and collaborative partners in the educational ecosystem (Ningtiaz et al., 2023) .

This study aims to analyse "Transformation of Science Learning with Digital-based Deep Learning". The focus of this study is directed at four primary schools, namely SMPN 1 Unaaha, SMPN 2 Unaaha, SMPN 1 Wonggeduku and SMPN 2 Wonggeduku in Konawe Regency. The four schools were chosen based on the consideration that each has initiated the integration of technology in the learning process, although the application is still limited to certain types of applications. This study aims to explore in depth the application of deep learning technology in the learning process in these schools, as well as identify the challenges faced and the benefits felt by educators and learners. Through this study, it is hoped that a comprehensive understanding of the application of deep learning technology in secondary education can be obtained, including the identification of challenges faced and alternative solutions that can be applied to encourage increased adoption of this technology in the Junior High School (SMP) environment.

It is expected that this study can make a significant contribution in expanding knowledge about the application of deep learning technology as a strategic approach to improving the quality of education provision at the junior secondary school (SMP) level. In addition, this study also aims to formulate recommendations that are strategic and applicable, which can be used as a reference by schools, local governments, and policy makers in planning and implementing the integration of these technologies in a comprehensive and appropriate manner.

RESEARCH METHODS

This research uses a descriptive qualitative approach with a case study method to examine the implementation of deep learning technology in learning activities in four junior high schools located in Konawe Regency, namely SMPN 1 Unaaha, SMPN 2 Unaaha, SMPN 1 Wonggeduku, and SMPN 2 Wonggeduku. The main objective of this study was to gain an in-depth understanding of how deep learning technology is implemented in learning and to identify the challenges and benefits experienced by teachers and students. Data was collected through in-depth interviews with principals, teachers, and students who were directly involved in the learning process using deep learning technology.

The interviews aimed to explore the experiences, views, and obstacles faced during the implementation of the technology. In addition, this research also involves participatory observation in the classroom to get a real picture of the implementation of deep learning in daily teaching and learning activities. Additional data was obtained through supporting documents related to the implementation of the technology, such as learning materials and student academic evaluation results (Sumarno & Nuroso, 2024) . All data collected was analysed using thematic analysis techniques to identify emerging patterns around the implementation of deep learning, obstacles faced, and perceived benefits (Ningtiaz et al., 2023) . This analysis is expected to provide a comprehensive picture of the implementation of deep learning technology at the junior high school level.

RESULTS AND DISCUSSION

The application of deep learning technology in Konawe Regency Junior High School has contributed significantly to improving the quality of learning, although its use is still limited in scope. The deep learning technology applied in the four schools SMPN 1 Unaaha, SMPN 2

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Unaaha, SMPN 1 Wonggeduku, and SMPN 2 Wonggeduku focuses on personalised learning as well as automated assessments that utilise data to create a learning experience that better suits the individual needs of each student.

In each of these schools, deep learning-based tools such as Google Classroom, Quizlet, and Kahoot! are used to support the learning process. These tools allow for more effective management of learning and provide interactivity and quicker feedback for students. The research findings indicate that the application of these technologies provides significant benefits, but also presents a number of challenges that must be overcome for the potential of technology in education to be maximised.

Results

Table.1. Interview Instrument with Classroom Teacher.

Aspects Explored	Interview Questions
Understanding Deep Learning	How do you understand the concept of deep learning in learning?
Digital Readiness	To what extent are your infrastructure and digital skills ready to implement deep learning technology at school?
Use of Technology	What digital technologies or applications have been used in science learning, and how are they used?
Impact on Learning	What are the perceived changes in the science learning process after the use of deep learning technology?
Student Motivation and Interest	Does the use of this technology have an impact on students' interest and motivation in learning science?
Implementation Challenges	What are the challenges or obstacles faced in implementing deep learning technology in science learning?
Support and Training	Did you receive any training or support from the school/government in implementing this technology?
Evaluation and Assessment	How is the learning evaluation method done with the support of deep learning technology?
Collaboration and Interaction	Does this technology support collaboration between students or between teachers and students in science learning?
Expectations and Recommendations	What are your hopes and recommendations regarding the development of the use of deep learning technology in the future?

1. Google Classroom Implementation

Google Classroom has been adopted as the main platform for learning management in the schools in this study. In SMPN 1 Unaaha, SMPN 2 Unaaha, SMPN 1 Wonggeduku, and SMPN 2 Wonggeduku, the platform is optimally utilised in the organisation of learning materials, assignments, and the delivery of direct feedback to learners. Particularly at SMPN 1 Unaaha, the use of Google Classroom was expanded to support the crucial distance learning process, especially during the pandemic. The use of the platform allows teachers to monitor students' learning progress in real-time as well as provide additional materials based on the results of data analysis. For example, if a student is having difficulty in understanding certain material, the teacher can provide supporting materials or reinforcement tasks to deepen the student's understanding of the concept. In addition, the system also facilitates collaboration

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between students through discussions and group work, both online and offline, thus supporting a more interactive and participatory learning process.

2. Using Quizlet for self-paced learning

Quizlet is one of the main learning tools implemented in SMPN 2 Unaaha, SMPN 1 Wonggeduku, and SMPN 2 Wonggeduku. It functions as a flashcard-based learning media designed to deepen students' understanding of various subject topics. By utilising deep learning algorithms, Quizlet is able to analyse students' learning achievements and present exercises tailored to individual performance. For example, if a student has difficulty in understanding certain concepts in science subjects, the system will automatically provide more targeted exercises on the material to strengthen the student's understanding. In addition to strengthening the personalisation aspect of the learning process, Quizlet also contributes to the development of students' learning independence, given that this platform allows learners to access various exercises and quizzes flexibly, both during class hours and outside formal learning time. This freedom in timing is a crucial component in supporting the creation of a self-paced learning experience. Furthermore, through the spaced repetition feature, Quizlet systematically organises the repetition of material at appropriate time intervals, so as to strengthen memory and increase the effectiveness of the student learning process.

3. Using Kahoot to Increase Student Engagement

In SMPN 1 Unaaha, SMPN 2 Unaaha, SMPN 1 Wonggeduku, and SMPN 2 Wonggeduku, the Kahoot application was utilised as a means of integrating gamification elements in the learning process, which proved effective in increasing student learning motivation. The use of Kahoot creates a fun learning atmosphere through interactive quizzes based on lesson content, which encourages active student participation through a competitive mechanism. Each question presented in this platform is accompanied by immediate feedback, so students can immediately know the success rate of their answers, accelerating the internalisation process of the material being learned. In addition, the reporting and analysis features available on Kahoot provide useful diagnostic data for teachers to evaluate student learning achievements, identify common obstacles faced, and determine learning areas that require additional intervention.

4. Integration of Deep Learning in Science Learning in Junior High School (SMP)

Figure.2. Deep Learning Framework

Science learning at the junior high school level plays a strategic role in shaping students' understanding of science concepts that have an impact on the progress of a nation. Therefore, strengthening science literacy in the context of junior high school education is a very crucial aspect. In the learning process, teachers play a role in guiding students to understand the essence of scientific phenomena by linking them to the context of everyday life. Along with the development of information technology, the approach to learning science has undergone a

significant transformation compared to the previous conventional method. Today, students have wider access to digital learning resources, including during the pandemic, where online learning is the main solution. This technology-based learning also contributes to students' understanding of contemporary global conditions. In an information age characterised by acceleration and complexity, mastery of natural science is key in shaping a critical and thoughtful perspective on ongoing global issues.

The implementation of deep learning principles in teaching science has a very important role in increasing students' motivation and understanding of the material taught. This phenomenon is in accordance with students' preferences that show a positive response to learning methods that are interactive, contextual, and have deep meaning. One of the strategic efforts that can be made by educators to realise contextual and interesting science learning is to integrate the use of information technology into the learning process. Such technology includes various digital resources, including links to educational sites (e.g. Google), which allow the delivery of learning materials in a more dynamic and contextual manner, so that it is not limited to conventional methods such as the lecture method. The utilisation of information technology needs to be aligned with the geographical conditions and environmental characteristics of each education unit. As a branch of science based on facts and evidence, IPA encourages learners to be active in finding and verifying information using internet-based technology. In its implementation, students can collect various scientific data and facts to be processed into narratives or creative products, such as educational videos, which are able to present science concepts contextually and relevant to today's life through the use of digital devices and internet connectivity. Through the application of the deep learning approach, teachers gain the ability to monitor students' academic progress in real time, so that pedagogical interventions can be made immediately if obstacles are found in the learning process.

The findings from the monitoring also form the basis for designing appropriate enrichment and remedial materials, with the aim of helping students overcome learning deficits. In addition, apps like Kahoot! provides immediate feedback based on the results of quizzes taken by students, which is very useful for teachers in evaluating students' level of understanding on certain learning topics. In addition, the deep learning approach integrates gamification elements that create a learning environment with healthy competition, which is proven to be effective in increasing students' learning motivation, focus and active engagement in learning activities. Nevertheless, the implementation of this technology is not free from challenges, especially for educators who have not fully mastered the use of deep learning-based tools and applications. Some teachers expressed challenges in implementing technology in the learning process, especially related to the optimal utilisation of Google Classroom features. Therefore, there is a need for continuous training programmes to increase teachers' capacity to utilise technology optimally in supporting the learning process.

Discussion

The findings from this study indicate that the application of accessible *deep learning* technologies, such as Google Classroom, Quizlet, and Kahoot!, has a discernibly positive impact on the educational landscape within Konawe Regency junior high schools. The successful integration of these tools for personalized learning and automated assessment demonstrates a significant step towards modernizing pedagogical practices. The core contribution of this technology lies in its ability to shift the learning paradigm from a traditional, teacher-centric model to a more dynamic, student-centered experience. By leveraging data to tailor educational content and provide immediate feedback, these platforms effectively address individual student needs and foster a more interactive environment (Hilmi, 2024; Owen & Licorish, 2020; Özdemir, 2024). This suggests that even with limited scope, the strategic

implementation of *deep learning* tools can serve as a powerful catalyst for enhancing the quality and effectiveness of the teaching and learning process in secondary education.

A key aspect highlighted by the results is the significant potential of these technologies to facilitate personalized and self-paced learning. The use of Quizlet, for instance, exemplifies this shift by employing algorithms to analyze student performance and deliver targeted exercises, thereby reinforcing concepts where a student shows weakness. This adaptive approach ensures that learning is not a one-size-fits-all process but is instead tailored to the unique learning trajectory of each individual. This fosters greater student autonomy, as learners are empowered to access materials and practice at their own pace, both inside and outside the classroom. The implementation of such tools supports the development of independent, self-regulated learners, which is a crucial objective of 21st-century education. This personalization is instrumental in building a deeper and more durable understanding of complex subject matter, particularly in the sciences (Kusrianto et al., 2025; Kustyarini et al., 2020).

Furthermore, the study underscores the profound impact of *gamification* on student engagement and motivation, as evidenced by the successful implementation of Kahoot!. By transforming formative assessments into competitive and interactive games, the application creates a learning atmosphere that is both enjoyable and intellectually stimulating. This approach effectively captures students' attention and encourages active participation, turning what might be a passive review session into a dynamic and memorable event. The provision of immediate feedback within the game-like structure allows students to self-correct in real-time, accelerating the learning cycle (Creel et al., 2021; Rojabi et al., 2022). The diagnostic data generated also provides teachers with valuable insights into class-wide comprehension and specific areas of difficulty, enabling them to make informed, data-driven adjustments to their instructional strategies, thereby enhancing the overall effectiveness of their teaching.

The integration of these *deep learning* technologies precipitates a fundamental transformation in the role of the teacher. Instead of being the primary dispenser of information, the teacher evolves into a *facilitator* of learning. Platforms like Google Classroom automate administrative tasks such as distributing materials and collecting assignments, freeing up valuable time for educators. The real-time data analytics provided by these tools empower teachers to monitor student progress more effectively and identify learning gaps almost instantly. This allows them to shift their focus from delivering standardized lectures to providing personalized support, guiding collaborative projects, and fostering critical thinking skills. This evolution is critical, as it aligns the teacher's role with the demands of modern pedagogy, where the emphasis is on guiding students to become active constructors of their own knowledge (Isnata, 2025; Lawitta & Najdah, 2025).

Despite the significant benefits, the research also brings to light a critical challenge that hinders the full potential of this technological integration: the varying levels of teacher readiness and digital literacy. The findings indicate that while the tools are available, their optimal utilization is often constrained by educators who have not yet fully mastered their features and pedagogical applications. Some teachers expressed difficulties, particularly with leveraging the more advanced functionalities of platforms like Google Classroom. This highlights a crucial gap between the availability of educational technology and the capacity of educators to effectively integrate it into their teaching practices. It underscores the fact that technology alone is not a panacea; its success is inextricably linked to the skills and confidence of the teachers who use it (Zaskia et al., 2025).

The implications of this study are significant for educational policy and practice. The findings suggest that a strategic investment in accessible *deep learning* technologies can yield substantial improvements in learning quality, even in non-metropolitan areas. This provides a

strong case for school administrators and government bodies to support the broader adoption of these tools. However, the research also makes it clear that such initiatives must be coupled with robust and continuous professional development programs for teachers. Training should not be a one-time event but an ongoing process that helps educators build their digital competencies and develop innovative pedagogical strategies that leverage technology effectively. A dual investment in both technological infrastructure and human capital is essential for a successful and sustainable digital transformation in education (Díaz-Suárez et al., 2025; El-Hamamsy et al., 2023; McCarthy et al., 2023).

In conclusion, this study effectively demonstrates the positive impact of integrating *deep learning* tools in junior high school science education, while also identifying key challenges. However, it is important to acknowledge the limitations of this research. The study's scope was confined to four schools within a single regency, which limits the generalizability of the findings to a wider population. The research methodology was also primarily descriptive, relying on interviews and observations. Future research would benefit from employing a quasi-experimental design to quantitatively measure the impact of these technologies on specific student learning outcomes, such as test scores and retention rates. A longitudinal study could also provide valuable insights into the long-term effects of this technology integration on both student achievement and teacher development.

CONCLUSIONS

The implementation of deep learning technology in the learning process at Konawe Regency Junior High School (SMP) shows positive results although it is still implemented in a limited scope. The technology plays an important role in strengthening the personalisation of learning through the ability to adjust learning materials according to the individual needs and abilities of each student. In addition, the use of deep learning also facilitates real-time monitoring of student progress as well as the provision of faster and more accurate feedback, thus increasing student motivation and engagement in learning activities. However, the implementation of this technology faces various obstacles, such as limited technological infrastructure, inadequate hardware and internet networks, and lack of training for teachers in operating deep learning-based systems. Nevertheless, the significant potential of this technology in improving the quality of education at the junior secondary school level is clear, especially in terms of personalising learning and evaluating the effectiveness of the learning process.

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