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Literature Study of the Deep Learning Approach in Vocational Schools: Implementation, Impact, and SWOT Analysis

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A B S T R A C T

The development of digital technology and the needs of modern industry have encouraged vocational education institutions to adopt more innovative learning approaches that are oriented towards the development of in-depth competencies. This study aims to analyze in-depth learning approaches in vocational education through a literature review covering implementation, impact, and analysis of strengths, weaknesses, opportunities, and threats. This approach has been proven to improve conceptual understanding, reflective skills, the connection between material and the real world, and the use of artificial intelligence technology that supports adaptive learning, learning path recommendations, student achievement predictions, and learning analytics. The results of the study show that deep learning has a positive impact on improving student competence and readiness to face the demands of modern industry, although there are still challenges in the form of infrastructure limitations, educator readiness, technology access gaps, and data ethics and privacy issues. The success of implementing this approach is highly dependent on strategic planning, improving the capacity of educators, and collaboration between educational institutions, the government, and industry so that it can support the transformation of learning towards a more adaptive and sustainable direction

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INTRODUCTION

The development of artificial intelligence (AI) technology has brought significant changes to vocational education, including vocational high schools (SMK) (Latif et al., 2025; Romadin et al., 2025). ne of the rapidly developing technologies that has had a major impact on education is Deep Learning, a branch of machine learning that uses artificial neural networks to recognize patterns and make decisions automatically. In the context of vocational education, the integration of Deep Learning not only improves the quality of learning but also strengthens students' readiness to face the demands of Industry 4.0 and 5.0, which are based on automation, data, and artificial intelligence.

The implementation of Deep Learning has two important dimensions in vocational education: the technological dimension and the pedagogical dimension. In the technological dimension, AI-based adaptive learning systems are capable of providing personalized learning experiences for students. Adaptive systems that utilize deep learning are capable of compiling personalized learning path recommendations for each student. With the ability to continuously analyze learning patterns, this system not only improves the efficiency of the learning process, but also encourages optimal student engagement through materials and strategies that are tailored to the needs, abilities, and development of each individual (Du, 2025). These findings are reinforced by (Y. Li & Leong, 2024; Peng & Guo, 2025), which shows that Deep Learning-based personalization improves retention, motivation, and overall learning effectiveness.

In the pedagogical dimension, Deep Learning in vocational schools is associated with learning strategies that encourage deep understanding, critical analysis, and reflective abilities in students. Tsai et al. (2022) emphasize that the development of an artificial intelligence-based curriculum with a deep learning approach can increase the interest, understanding, and satisfaction levels of students in vocational schools. The integration of this technology makes the learning process more relevant, interactive, and aligned with students' needs and characteristics, thereby making the learning experience more meaningful and effective. Other studies by (Apoko et al., 2025; Nurlaela et al., 2025; Yoto et al., 2024) also show that the deep learning approach helps students develop more meaningful learning engagement. In addition, the deep learning approach also extends to the realm of character and values education. Deep learning strategies help the process of internalizing values through reflection, context exploration, and deep conceptual engagement (Panuntun, 2025). hus, the integration of deep learning is not only technical in nature but also supports the formation of students' ethics, character, and professional attitudes.

Various studies have confirmed the positive impact of Deep Learning in vocational school learning. In terms of efficiency, deep learning models accelerate material completion by up to 25% and increase student retention by up to 30% (Yuan, 2024). In terms of learning outcomes (Jing et al., 2024) found that deep learning-based learning methods significantly improve the academic achievement and practical skills of vocational students. Even in inclusive education, (Mulyanti et al., 2026) eported that deep learning models are effective

in accommodating students with special needs due to their adaptive and data-driven nature.

Although it offers many benefits, the implementation of Deep Learning in vocational schools faces a number of challenges, particularly related to teacher readiness and school infrastructure. (Zhang et al., 2024) mphasizes that teacher readiness and adaptability to technology remain major obstacles in the application of deep learning systems in vocational education. However, research by (Panuntun, 2025) and (Sodikin, 2025) shows that continuous training, flexible curriculum design, and the development of technology-based digital modules can be effective solutions in overcoming these obstacles.

LITERATURE REVIEW

From a research perspective, the trend of Deep Learning development in vocational education continues to increase from 2022 to 2025, as shown in various international publications (Feng, 2022; Sun et al., 2023; Tang, 2024; Tsai et al., 2022). This growth in research indicates that Deep Learning is gaining attention as a key approach in creating adaptive, efficient learning that is relevant to industry needs. Overall, the integration of Deep Learning in vocational school education not only responds to the demands of educational digitization, but also provides a learning framework that enables students to develop technical, cognitive, and character competencies more deeply. This transformation is an important foundation for building the quality of vocational school graduates who are able to compete and contribute in the modern industrial world.

METHODOLOGY

The research method used in this study was a literature study with a descriptive-analytical approach. This study focused on collecting and reviewing various scientific sources related to the deep learning approach in vocational high schools (SMK). The literature sources used included national and international journals, conference proceedings, textbooks, research reports, and vocational education policy documents. The literature search process was conducted through various databases such as Google Scholar, ERIC, and ScienceDirect using relevant keywords related to deep learning and vocational education.

The selection of literature was based on strict inclusion and exclusion criteria to ensure data quality and relevance. The inclusion criteria included publications published between 2013 and 2025, in Indonesian or English, with a clear methodology, and directly discussing the concept or application of deep learning in education. Conversely, literature that only mentions deep learning in the context of artificial intelligence (AI) technology without a pedagogical approach, or articles without full text, were excluded from the analysis. This selection process ensured that the literature analyzed truly supported the research objectives.

Data analysis in this study was conducted using descriptive-analytical techniques through several stages. First, trends were identified to understand the direction of development and focus of research related to deep learning in vocational education. Second, the implementation of this approach in vocational school learning was analyzed, including learning strategies, supporting

technologies, and the role of teachers in facilitating deep learning. Third, the impact of deep learning implementation was assessed based on improvements in students' critical thinking, creativity, collaboration, and work readiness. Next, a SWOT analysis was conducted to evaluate the strengths, weaknesses, opportunities, and threats of implementing this approach.

To maintain data validity, source triangulation is carried out by comparing the results of various analyzed literature. Cross-checking is done to ensure consistency and reliability of findings between studies, while peer review is used to obtain input from vocational education experts. The findings were then synthesized into a comprehensive narrative describing the trends, implementation, impact, and results of the SWOT analysis related to the application of deep learning in vocational schools. The final results of this study are expected to provide a comprehensive overview that can serve as a basis for the development of deep learning-based vocational education policies and practices in the future.

RESULTS AND DISCUSSION

The transformation of vocational education in the digital era requires a more adaptive and in-depth learning approach. This approach is known as deep learning, both as a pedagogical paradigm and as artificial intelligence (AI) technology. As a learning paradigm, deep learning encourages active engagement, creativity, problem solving, and meaningful learning (Apriliyana, 2025; Zebua, 2025). Meanwhile, as a technology, deep learning involves attention mechanism models that support personalized learning and data-driven decision-making in vocational education systems (Peng & Guo, 2025; Yuan, 2024). t the vocational school level, these two forms of deep learning are driving the modernization of curricula and learning approaches oriented towards the needs of industry 4.0 (Jia et al., 2022; Peng & Guo, 2025).

Implementation of Deep Learning in Vocational School Education

The deep learning approach is a learning paradigm that focuses on conceptual understanding, reflective abilities, and the relevance of material to real-world contexts. In the context of vocational education, this approach has been shown to have a positive impact on the learning process and outcomes of students. A number of studies show that vocational high school students respond well to the application of deep learning, especially in English and Islamic Religious Education subjects. This positive response is influenced by increased learning motivation, the relevance of the material to everyday life, and the internalization of important values in learning activities (Apoko et al., 2025; Panuntun, 2025). This proves that the deep learning approach is able to bridge the gap between theory and practice, while helping students understand the meaning behind their learning process.

The application of four key elements in deep learning—real-world connections, personalized learning, collaboration among students, and the use of digital technology—are key factors that strengthen the quality of learning in vocational schools. The integration of these elements not only increases student engagement but also contributes significantly to the development of 21st-century

competencies, such as critical thinking, creativity, communication, and collaboration (Apriliyana, 2025). With the increasingly complex demands of the world of work, this approach trains students to become active learners who are able to integrate their learning experiences with real-world situations in industry.

In the field of technology and artificial intelligence (AI), the implementation of deep learning has also shown significant progress in vocational schools. The use of Python-based AIoT courses, virtual laboratories, and the application of innovative design models such as Double Diamond 4D, opens up new opportunities for students to understand modern technology concepts in a more practical way. A study conducted by (Tsai et al., 2022) shows that AIoT courses are effective in improving the competence of vocational school students, particularly in mastering industrial sensors, Python programming, and the basics of AI. This interactive and contextual learning experience allows students to explore advanced technologies through simulations and hands-on practice.

Strengthening the vocational school curriculum through a deep learning approach makes a real contribution to preparing students to compete in a technology-based world of work. Integrating deep learning into vocational subjects hones analytical skills, creativity in problem solving, and digital literacy, which are key requirements in the era of Industry 4.0 and 5.0. In line with the findings (Hasnida et al., 2024; Irfan et al., 2025; Samala et al., 2023; Sun et al., 2023; Suwardana, 2018), students involved in deep learning-based learning show a significant increase in work readiness, particularly in the fields of technology and engineering. Thus, deep learning is not only a pedagogical strategy but also an important foundation in the transformation of vocational education toward a more adaptive, innovative, and future-oriented learning model.

The integration of deep learning as part of artificial intelligence (AI) technology has brought about major changes in education systems, including at the vocational school level, which requires adaptive and competency-based learning. One important application is the development of adaptive learning systems that can automatically map students' learning needs. Through deep learning algorithms, the system can adjust the material, level of difficulty, and pace of learning according to each student's learning profile. This has been proven to improve the efficiency and quality of vocational learning, as each student receives a learning experience that is more suited to their abilities and learning style (Y. Li & Leong, 2024; Peng & Guo, 2025).

In addition, AI integration is also present in the form of course recommendation and learning path systems that use models such as Deep Q-Network (DQN). This model enables optimal learning path planning based on academic achievement and student abilities, making learning more personalized, responsive, and oriented towards individual development (Peng & Guo, 2025). eep learning-based recommendation systems also help students choose the subjects, modules, or skill competencies that best suit their learning profiles. This has a positive impact on vocational high school students who need career guidance and assistance in choosing the right vocational path from the outset (Yuan, 2024).

In the context of learning evaluation, deep learning technology is also used to predict student achievement and retention. Models such as CNN and RNN are capable of analyzing learning patterns, predicting grades, and even detecting students at risk of dropping out (Feng, 2022; Peng & Guo, 2025). The advantage of these predictive models lies not only in their high accuracy, but also in their ability to assist schools in making strategic decisions. By understanding risk factors early on, schools can provide appropriate interventions, such as additional tutoring, counseling, or recommendations for alternative learning paths.

Furthermore, deep learning also plays an important role in teacher evaluation and learning analytics. AI systems can comprehensively process learning data to assess teaching effectiveness, student engagement levels, and interaction patterns during learning. Deep learning-based learning analytics enable schools to identify areas of teaching that need improvement and design more optimal learning strategies(Peng & Guo, 2025; Zhang et al., 2024). The integration of this technology has a broad impact, not only on students, but also on teachers and educational institutions in improving the overall quality of learning management.

Table 1. Focus and implementation of Deep Learning approaches in vocational schools

No.	Focus/Applications	Examples of Implementation & Impact	Source
1.	Language & Values Learning	Increasing student motivation, relevance, and internalization of values	(Apoko et al., 2025; Panuntun, 2025).
2.	AI & Technology	AIoT courses, Python, virtual labs, industry competency improvement	(Apriliyana, 2025; Tsai et al., 2022)
3.	Adaptive Systems & Recommendations	Achievement predictions, personalized learning paths, course recommendations	(Hasnida et al., 2024; Irfan et al., 2025; Samala et al., 2023; Sun et al., 2023; Suwardana, 2018),
4.	Evaluation & Analytics	Teacher evaluations, learning analytics, data-driven management	(Peng & Guo, 2025; Zhang et al., 2024)

The Impact of Deep Learning Approaches on Vocational Schools

The application of deep learning approaches has been proven to improve conceptual understanding and higher-order thinking skills in vocational school students. According to (X. Li, 2025) students who learn using deep learning strategies show an increase in conceptual understanding of up to 35% compared

to traditional methods. Additionally, a study by Feng (Feng, 2022) revealed that exploration and reflection-based learning models can improve students' problem-solving skills, which are essential in vocational education. This shows that deep learning not only improves theoretical knowledge but also strengthens technical and applied skills.

Deep learning-based technology enables the creation of adaptive learning systems that tailor learning materials and pace to students' abilities. Research (Yuan, 2024) hows that deep neural network-based recommendation systems can improve the accuracy of learning material selection by up to 82%. Meanwhile, research (Peng & Guo, 2025) found that the use of Deep Q-Network (DQN) models improves the accuracy of students' learning paths and helps schools design more effective and individualized learning experiences. Thus, personalized learning has become one of the most significant impacts of deep learning implementation.

A learning environment that implements deep learning encourages students to think critically, creatively, collaboratively, and to be able to make decisions independently. According to (Balve & Ebert, 2019; Calero López & Rodríguez-López, 2020; Chou et al., 2023; Kenayathulla et al., 2019; Khurniawan & Erda, 2019) this approach strengthens employability skills such as problem solving, teamwork, and technological adaptation, which are in line with the needs of modern industry. This is important for vocational schools that have a primary focus on the world of work. In addition, this approach increases students' confidence in conducting project-based learning, especially in technological fields such as automation, basic AI, robotics, and manufacturing design.

The implementation of deep learning has an impact not only on students but also on teachers and educational management. A study (Xue, 2023) shows that learning analytics based on deep neural networks can help evaluate teaching effectiveness, predict student achievement patterns, and provide data-driven feedback. A study (Baumann et al., 2014) adds that schools that integrate AI-based learning analytics experience up to a 40% increase in academic decision-making efficiency. Thus, deep learning plays an important role in creating a more adaptive and responsive vocational learning ecosystem.

Table 2. The Impact of Deep Learning Implementation on Vocational Schools

No.	Impact Aspects	Impact Description	Researcher/Year
1.	Improved Academic Performance	Improved conceptual understanding and problem-solving skills	(X. Li, 2025) (Feng, 2022)
2.	Personalized Learning	Material recommendation systems, adaptive learning paths, automated evaluation	(Yuan, 2024) (Peng & Guo, 2025)

3	Student Work Readiness	Strengthened 21st-century skills, industry readiness, problem solving	(Balve & Ebert, 2019; Calero López & Rodríguez-López, 2020; Chou et al., 2023; Kenayathulla et al., 2019; Khurniawan & Erda, 2019)
4.	Education Management	Learning analytics, AI-based teacher evaluation, data-driven decisions	(Xue, 2023) (Baumann et al., 2014)

SWOT Analysis of Deep Learning Approach in Vocational Schools

The deep learning approach in vocational schools offers great potential for improving students' digital competence, critical thinking, and work readiness. The integration of artificial intelligence technology, project-based learning, and learning analytics enables a more personalized and adaptive learning experience. However, its implementation also faces challenges in terms of infrastructure, teacher training, and the readiness of the education system. Therefore, a SWOT analysis is needed to understand the strategic position of deep learning implementation in vocational schools.

Table 3. SWOT Analysis of the Deep Learning Approach in Vocational Schools

Aspect	Key Findings	Source
Strengths	- Improving students' digital skills and industry readiness - Supporting project-based learning and innovation - Facilitating integrated online learning management - Encouraging multi-stakeholder collaboration	(Apriliyana, 2025; Tsai et al., 2022)
Weaknesses	-Limited infrastructure and human resources - Lack of teacher training on deep learning and AI - High dependence on technology and data - Variations in students' reflective abilities and digital literacy	(Apoko et al., 2025; Panuntun, 2025).
Opportunities	- Government support for the digitization of vocational education - Development of AI and deep learning-based curricula	(Yuan, 2024) (Peng & Guo, 2025)

	- Collaboration with DUDI and the technology industry - Improving the relevance of graduates to industry needs	
Threats	- Fluctuating curriculum and education policy changes - Inequality in access to technology between regions - Ethical, data security, and privacy risks - Potential technology dependence and threats to academic integrity	(Xue, 2023) (Baumann et al., 2014)

Based on Table 3, it can be argued that the deep learning approach can strengthen project-based learning, exploration, and innovation because it encourages students to understand concepts deeply through reflection and real-world connections. Deep learning improves 21st-century competencies such as collaboration, creativity, and communication. In addition, the integration of digital technology strengthens a more interactive online learning ecosystem and provides opportunities for cross-school and industry collaboration.

The implementation of deep learning is often hampered by a lack of technological devices, internet networks, and digital laboratories, especially in vocational schools in rural areas. In addition, teachers do not yet fully understand how to design AI-based deep learning, so ongoing training is urgently needed. The unpreparedness of teachers is one of the biggest obstacles to learning transformation. Differences in students' digital literacy skills also create inequalities in the learning process.

The opportunities for applying deep learning are increasing in line with the government's push to accelerate the digitization of vocational education and collaboration with industry. The integration of AI, industrial sensors, and automation opens up opportunities to develop curricula that are more relevant to the needs of the job market. Vocational school graduates who understand basic AI, data analytics, and programming have the potential to be highly competitive in the era of Industry 4.0 and 5.0.

The biggest threat comes from rapid and inconsistent changes in curriculum policy, especially regarding the integration of technology in schools. The digital divide between regions also has the potential to deepen the gap in the quality of vocational education. In addition, the use of deep learning algorithms raises issues of data privacy and educational ethics, especially if students become too dependent on automated systems, thereby reducing their creativity and critical thinking skills. The risks of digital plagiarism and learning data manipulation also need to be considered.

CONCLUSION AND RECOMMENDATION

The deep learning approach in vocational education shows great potential for improving the quality of the learning process in vocational high schools. As a pedagogical approach, deep learning encourages students to think critically, understand concepts holistically, and connect subject matter to real-world situations in the workplace. Meanwhile, as an artificial intelligence technology, deep learning enables the creation of learning systems that adapt to student needs, provide learning path recommendations, predict academic progress, and support data-driven learning analysis. The integration of technologies such as convolutional neural networks, recurrent neural networks, and reinforcement learning algorithms has been proven to help personalize learning and improve the accuracy of educational evaluation.

Despite its great potential, the application of deep learning in vocational education still faces various challenges, particularly in terms of the availability of digital infrastructure, the readiness of educators, and the ability of educational institutions to manage data and maintain ethical use of technology. Therefore, the implementation of deep learning requires a well-planned strategy through the improvement of educator competencies, the provision of adequate technological facilities, and cooperation with industry and other stakeholders. With continuous support, deep learning has the potential to become an important foundation in shaping competent, adaptive graduates who are ready to face technological developments in the modern industrial era.

REFERENCES

Apoko, T. W., Setyawati, H., Assaadah, A., Kusumawaty, D., Parameswari, L. A., Lecturer, E., Muhammadiyah, U., Teacher, E., Teacher, E., Teacher, E., & Teacher, E. (2025). Exploring Indonesian Vocational Students' Perspectives On Deep Learning In English Language Education. Journal of English Language Teaching, 12(1), 49–61. https://doi.org/10.33394/joelt.v12i1.15155

Apriliyana, N. P. (2025). Transforming Education Through Deep Learning Design : Integrating Four Key Elements in School Practice. Molang: Journal Islamic Education is licensed under a Creative Commons.

Balve, P., & Ebert, L. (2019). Ex Post Evaluation of a Learning Factory - Competence Development Based on Graduates Feedback. Procedia Manufacturing, 31, 8–13. https://doi.org/10.1016/j.promfg.2019.03.002

Baumann, T., Harfst, S., Swanger, A., Saganski, G., Alwerfalli, D., & Cell, A. (2014). Developing Competency-based, Industry-driven Manufacturing Education in the USA: Bringing together Industry, Government and Education Sectors. Procedia - Social and Behavioral Sciences, 119, 30–39. https://doi.org/10.1016/j.sbspro.2014.03.006

Calero López, I., & Rodríguez-López, B. (2020). The relevance of transversal competences in vocational education and training: a bibliometric analysis. Empirical Research in Vocational Education and Training, 12(1). https://doi.org/10.1186/s40461-020-00100-0

Chou, C.-M., Shen, T.-C., Shen, T.-C., & Shen, C.-H. (2023). The impact of CIE education integrated with the BIG 6 teaching strategy on students' innovative motivation, creativity, metacognition, and self-perceived employability. Thinking Skills and Creativity, 48, 101287. https://doi.org/https://doi.org/10.1016/j.tsc.2023.101287

Du, W. (2025). An adaptive learning path recommendation framework based on deep learning for AI-driven vocational English education (Vol. 13682). https://doi.org/10.1117/12.3074083

Feng, W. (2022). Intelligent Vocational Education System Based on Deep Learning. 2022 International Conference on Knowledge Engineering and Communication Systems (ICKES), 1–6. https://doi.org/10.1109/ickecs56523.2022.10060364

Hasnida, S. S., Adrian, R., & Siagian, N. A. (2024). Transformasi Pendidikan di Era Digital. Jurnal Bintang Pendidikan Indonesia, 1(1), 1–11. https://kumparan.com/aan-herdian89/transformasi-pendidikan-di-era-digital-1zG74Ilpzc4/4

Irfan, A. M., Anwar, B., Anwar, F., Romadin, A., & Fuadah, N. (2025). Pelatihan Pengembangan Micro Modul Digital Berbasis Case Methode Di SMKN 8 Pinrang. JPKMN, 6(3), 4346–4357.

Jia, F., Sun, D., Ma, Q., & Looi, C. K. (2022). Developing an AI-Based Learning System for L2 Learners' Authentic and Ubiquitous Learning in English Language. Sustainability (Switzerland), 14(23). https://doi.org/10.3390/su142315527

Jing, C., Kaur, C., & Singh, S. (2024). Enhancing Academic Achievement in Computer Science Students : An Experimental Study on the Efficacy of Deep Learning Teaching Methods in Higher Vocational Education. International Journal of Education and Humanities, 15(2).

Kenayathulla, H. B., Ahmad, N. A., & Idris, A. R. (2019). Gaps between competence and importance of employability skills: evidence from Malaysia. Higher Education Evaluation and Development, 13(2), 97–112. https://doi.org/10.1108/heed-08-2019-0039

Khurniawan, A. W., & Erda, G. (2019). Potret Tenaga Kerja Lulusan SMK Pada Industri Manufaktur. Distribution, January, 1–23.

Latif, N., Romadin, A., & Irfan, A. M. (2025). Pelatihan Pemanfaatan AI bagi Guru SMKN 8 Pinrang untuk Meningkatkan Inovasi Modul Pembelajaran Era Metaverse. Ihsan: Jurnal Pengabdian Masyarakat, 7(1). https://doi.org/10.30596/ihsan.v

Li, X. (2025). Design and implementation of a vocational education English adaptive teaching system based on deep learning and optical technologies. 13682, 136823. https://doi.org/10.1117/12.3073828

Li, Y., & Leong, W. Y. (2024). Improvement of AI-Driven Deep Knowledge Tracing Algorithms. 2024 International Conference on Intelligent Education and Intelligent Research (IEIR), 1–6. https://doi.org/10.1109/ieir62538.2024.10959805

Mulyanti, B., Widiaty, I., & Wulandari, I. Y. (2026). Teacher Perceptions of Deep Learning Models for Special Need Students in Inclusive Vocational Schools : A Fuzzy Logic Analysis. Journal of Advanced Research in Applied Sciences and Engineering Technology, 1(1), 112–121.

Nurlaela, N., Nawi, M. Z. M., & Romadin, A. (2025). Effectiveness of E-Module and Learning Style on Self- Regulation Learning Model to Increase the Occupational Safety and Health Knowledge for Mechanical Education Students. JTET, 17(3), 189–203.

Panuntun, S. (2025). Implementation of deep learning strategy in islamic religious education to internalize islamic values at smk hisba buana semarang. At Turots: Jurnal Pendidikan Islam, 7(1), 110–123.

Peng, F., & Guo, L. (2025). Personalized learning path planning and optimization methods of vocational education combined with DQN. Journal of Computational Methods in Sciences and Engineering, 25, 3780–3792. https://doi.org/10.1177/14727978251323112

Romadin, A., Cahyani, V. P., Anwar, F., & Erniyani, E. (2025). Strategies for Understanding Vocational High School Learners Through Identification of Self Characteristic. Internasional Journal of Integrative Sciences (IJIS), 4(2), 279–288.

Samala, A. D., Usmeldi, Taali, Ambiyar, Bojic, L., Indarta, Y., Tsoy, D., Denden, M., Tas, N., & Dewi, I. P. (2023). Metaverse Technologies in Education: A Systematic Literature Review Using PRISMA. International Journal of Emerging Technologies in Learning, 18(5), 231–252. https://doi.org/10.3991/IJET.V18I05.35501

Sodikin, A. (2025). Implementation of Deep Learning Approaches : Challenges and Solutions for Teachers Implementasi Pendekatan Deep Learning : Tantangan dan Solusi Bagi Guru. RADIANT Journal of Applied, Social, and Education Studies, 6(2), 134–146.

Sun, Y., Huang, W., Wang, Z., Xu, X., Wen, M., & Wu, P. (2023). Smart Teaching System: A Hybrid Framework of Reinforced Learning adn Deep Learning. Learning, Emerging Technologies in, 18(20), 37–50.

Suwardana, H. (2018). Revolusi Industri 4. 0 Berbasis Revolusi Mental. JATI UNIK : Jurnal Ilmiah Teknik dan Manajemen Industri, 1(1), 102. https://doi.org/10.30737/jatiunik.v1i2.117

Tang, H. (2024). Construction of vocational undergraduate education teacher team based on deep learning. Journal of Computational Methods in Sciences and Engineering, 24, 201–216. https://doi.org/10.3233/JCM-237041

Tsai, C., Chung, C., & Cheng, Y. (2022). Deep learning course development and evaluation of artificial intelligence in vocational senior high schools. Frontiers in Psychology, September, 1–18. https://doi.org/10.3389/fpsyg.2022.965926

Xue, F. (2023). Research on the Application of Reinforcement Learning Model in Vocational. Journal on Artificial Intelegence. https://doi.org/10.32604/jai.2023.046293

Yoto, Y., Suyetno, A., Ardista, P., & Romadin, A. (2024). The role of industry to unlock the potential of the Merdeka curriculum for vocational school. Cogent Education, 11(1). https://doi.org/10.1080/2331186X.2024.2335820

Yuan, S. (2024). Design and Implementation of a Vocational Education Course Recommendation System Based on Deep Learning. 2024 5th International Conference on Information Science and Education (ICISE-IE), 153–156. https://doi.org/10.1109/icise-ie64355.2024.11025485

Zebua, N. (2025). Education Transformation : Implementation of Deep Learning in 21st-Century Learning. Harmoni Pendidikan: Jurnal Ilmu Pendidikan, 2(2), 146–152.

Zhang, Y., Sun, X., & Yu, J. (2024). Transformative Technologies in the Evaluation of a Vocational Education System. Journal ofWeb Engineering, 23, 275–298. https://doi.org/10.13052/jwe1540-9589.2324