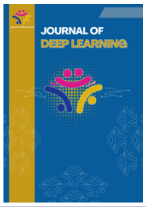

Journal of Deep Learning

https://journals2.ums.ac.id/index.php/jdl

Strategies and Development of the Deep Learning Approach in Vocational High Schools in the Era of Global Computing

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DOI: xxx

Received: April 10th, 2025. Revised: May 20th, 2025. Accepted: May 28th, 2025

Available Online: June 8th, 2025. Published Regularly: June, 2025

Abstract

The transformation of vocational education in the era of the Industrial Revolution 4.0 demands the integration of learning approaches that go beyond cognitive aspects to include affective and contextual dimensions. This study aims to formulate relevant and applicable strategies for developing a deep learning approach tailored to Vocational High Schools (SMK) in Indonesia. Drawing on the principles of mindful, meaningful, and joyful learning, this research presents a conceptual and practical synthesis that can be implemented in vocational education. The findings indicate that project-based learning, digital reflection, and cross-disciplinary collaboration are effective strategies in fostering students' conceptual understanding and applied skills. Authentic assessments based on portfolios, presentations, and reflective journals are also deemed more representative in measuring deep learning outcomes. On the other hand, teacher capacity-building through transformative pedagogical training, socio-emotional reinforcement, and the formation of Professional Learning Communities is essential for successful implementation. The integration of digital technologies in vocational learning has proven to expand learning spaces and strengthen the connection between schools and industries. This study recommends strengthening policy and infrastructure support to ensure the sustainability of the deep learning approach in SMK as an adaptive, reflective, and relevant learning strategy in the digital era.

Keywords: deep learning, joyful learning, mindful learning, meaningful learning, learning transformation, project-based learning, pedagogical innovation, technology integration

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1. Introduction

The rapid development of technology and the internet has brought about major transformations in various aspects of life, including education (Islam & Habib, 2021; Rahmadi et al., 2024). Over the past two decades, advancements in information and communication technology have had a significant impact on the global education system, including at the vocational high school (SMK) level. Educational reform has become crucial to equip students with 21st-century skills such as critical thinking, communication, collaboration, and creativity (Fitriansyah et al., 2020; Maghfiroh et al., 2023). Amid the era of digital globalization and the Fourth Industrial Revolution, as well as the emergence of Artificial Intelligence (AI), labor market demands have also shifted: not only are technical skills required, but also adaptive abilities and reflective thinking (Schwab, 2017).

In response to these challenges, the adoption of a deep learning-based instructional approach has become increasingly relevant and

urgent. In a pedagogical context, deep learning does not merely refer to technology but rather to a learning approach that emphasizes deep conceptual understanding, the development of critical thinking skills, and problem-solving abilities (Fullan & Langworthy, 2014). Unfortunately, current realities show that many vocational high school (SMK) graduates are not yet fully prepared to face the demands of the digital workforce. This is largely due to the predominance of surface learning practices, which focus on memorization and information reproduction without deep comprehension (Biggs & Tang, 2011). Therefore, the integration of technology with the deep learning approach has become a strategic necessity in vocational education reform to produce graduates who are competent, resilient, and innovative.

The education curriculum is expected to adapt dynamically to the disruptions caused by digital technology (Hidayat et al., 2025). However, implementation in the field continues to face challenges. Many vocational high schools (SMKs) in Indonesia have yet to adopt learning strategies that align with the needs of the digital industry. Previous studies have found that learning processes are still dominated by teacher-centered approaches, limited implementation of project-based learning, and low levels of student engagement (Rohendi & Daryanto, 2019; Kurniawati et al., 2021). According to Ahmad et al. (2020), most vocational educators have not yet fully grasped the principles of deep learning, which are rooted in constructivist, contextual, and integrative approaches. In fact, this approach has been proven effective in enhancing conceptual understanding and higher-order thinking skills (Hattie & Donoghue, 2016).

Although the potential of deep learning in vocational education has been acknowledged, its implementation in vocational high schools (SMKs) remains very limited. Barriers include teachers' low level of understanding, inadequate technological infrastructure, and the lack of adaptation of deep learning methods to the vocational context (Wibawa et al., 2023). This situation creates a significant research gap, namely the absence of a contextually designed deep learning implementation model that aligns with the characteristics of vocational education and the needs of the 21st-century digital industry.

Most previous studies have focused primarily on the digitalization of learning without integrating transformative pedagogical frameworks such as deep learning. For example, the study by Zainuddin and Perera (2019) emphasized the flipped classroom approach in a vocational context but did not address the cognitive and reflective aspects of deep learning. Moreover, many teaching approaches have been generalized without adequately balancing theory and practice, as well as the hard skills and soft skills that characterize vocational education. Therefore, the uniqueness of this study lies in its interdisciplinary approach, which combines the principles of deep learning with the concrete needs of the digital industry, while also considering the social, cultural, and economic dimensions that influence the learning environment in vocational high schools (SMK).

The purpose of this study is to formulate a contextual, practical, and relevant strategy for developing the deep learning approach in vocational high schools (SMK) to address the challenges of digitalization and globalization. This study aims to identify the key aspects of the deep learning approach that can be effectively applied in vocational education, while also assessing the readiness of vocational education institutions to adopt this approach. Furthermore, the research designs a strategic

framework that bridges the demands of deep learning with the requirements of the digital industry, ensuring that the developed approach is not only theoretical but also applicable in accordance with the characteristics of SMK and technological advancements.

As stated by Marton and Säljö (1997), deep learning encourages students to actively construct meaning and relate new information to their prior experiences—an approach that is highly compatible with the practice-based learning characteristics in vocational high schools (SMKs). This study is expected to provide both theoretical and practical contributions, particularly for teachers, school principals, curriculum developers, and policymakers in designing future learning strategies.

This study not only contributes to the literature on vocational education and innovative pedagogy but also offers significant practical implications. The increased adoption of the deep learning approach is expected to strengthen the readiness of vocational high school (SMK) graduates in facing dynamic technological changes and to foster the emergence of a generation of innovators. As emphasized by Van Der Vleuten et al. (2010), the transformation of learning paradigms toward more meaningful approaches will produce graduates who are not only technically competent but also reflective and adaptive to chang.

The strategy for developing the deep learning approach should not be viewed as a short-term response to technological advancements but rather as a strategic step to redefine the direction of vocational education to be more contextual, holistic, and sustainable. Within this framework, vocational high schools (SMKs) play a crucial role not only as providers of skilled labor but also as drivers for the emergence of young innovators capable of competing on the global stage.

2. Method

This study employs a qualitative approach using an exploratory case study method to develop a strategy for implementing the deep learning approach within the context of Vocational High Schools (SMK). This approach was chosen because it allows the researcher to deeply explore learning phenomena in SMK, particularly regarding the integration of mindful, meaningful, and joyful learning aspects in the teaching and learning process. The research was conducted in three public SMK in Central Java that have implemented a digital technology based curriculum revitalization program. The research informants consisted of 9 productive subject teachers, 3 program heads, and 45 students from the expertise competencies of Computer and Network Engineering and Software Engineering. The subjects were purposively selected based on their active involvement in learning innovations and technological readiness.

Data were collected through classroom observations, in-depth interviews, and documentation. Observations were conducted to record teaching practices that reflect the elements of mindful, meaningful, and joyful learning. Interviews were used to explore teachers' and students' perceptions of their learning experiences, while documentation was examined to analyze syllabi, lesson plans (RPP), and student project products. Data analysis was conducted using thematic analysis techniques following Miles and Huberman's (1994) approach, which includes data reduction, data display, and conclusion drawing/verification. Initial codes were developed based on the three main learning categories (mindful, meaningful, and joyful learning), and subthemes were elaborated through data triangulation.

Data validity was maintained through source and technique triangulation, member checking, and audit trails. Triangulation was done by comparing results from observations, interviews, and documents. Member checking was carried out with key informants to ensure data accuracy and alignment with their perceptions.

To effectively implement the deep learning approach in SMK environments, a concrete understanding is required regarding how the principles of mindful, meaningful, and joyful learning can be operationalized in learning practices. Each approach reflects complementary cognitive, affective, and social aspects that foster a more holistic and transformative learning experience for students. Therefore, to ensure the systematic and measurable integration of these three approaches, it is important to formulate operational indicators that can be used as references in the planning, implementation, and evaluation of learning.

The following table summarizes the operational indicators of each approach, along with key aspects and examples of learning activities that can be applied within the vocational education context at SMK:

Table 1. Operational Indicators of Mindful, Meaningful, and Joyful Learning in the Context of Vocational High Schools

Approach	Main Aspects	Operational Indicators	Activity Examples
Mindful Learning	Reflection and self-awareness	Students demonstrate awareness of thinking and learning processes; reflect after practice or discussion; are able to ask critical questions.	Reflective journal after practice, metacognition discussion, Q&A forum
	Metacognition and adaptation	Students are able to explain the reasons for actions or decisions in learning activities; adjust learning strategies when facing problems.	Group discussion for evaluation of technical problem solving approaches
Meaningful Learning	Connection with prior knowledge	Students demonstrate the ability to relate new content to prior knowledge or experiences and comprehend the underlying meaning of procedures	Concept mapping and the use of advance organizers prior to practice
	Contextual and applicable	Students demonstrate the ability to solve tasks grounded in real-world contexts, engaging in learning through case studies and industry simulation	Case-based practicum and industry simulation based on IoT (Internet of Things)
Joyful Learning	Positive emotions and engagement	Students demonstrate enthusiasm for learning; feel comfortable working in teams; and show motivation when engaging in project-based activities	Educational games, thematic ice-breaking activities, and game-based learning
	Creativity and interactivity	Students exhibit active participation, display creativity in problem-solving or project completion, and collaborate effectively within group settings	Collaborative projects, exhibitions of student work, and interactive presentations

3. Result and Discussion

A. Learning Strategies Using the Deep Learning Approach

Deep learning in the field of education has a meaning distinct from the technical definition used in artificial intelligence. According to Biggs and Tang (2011), deep learning involves a learning method where students do not merely memorize material but also comprehend, connect concepts, analyze, and apply knowledge critically and creatively. This approach encourages students to generate ideas, link various topics or subjects, apply concepts in real-world situations, and engage in reflective and independent thinking. This method is especially crucial in the context of vocational high school (SMK) learning, as it closely relates to workforce demands requiring deep understanding and practical skills (Marton & Säljö, 1997; Entwistle, 2000; Entwistle & Peterson, 2004).

The implementation of the deep learning approach in SMK education is carried out through various strategies. Project-Based Learning (PjBL) is a model that encompasses critical elements of deep learning, allowing students to integrate theory with practice. Thomas (2000) states that PjBL enhances students' capacity to solve complex problems and strengthens higher-order thinking skills. Teachers from various subjects collaborate in designing collaborative projects to reinforce connections between concepts, which is a hallmark of deep learning (Krajcik & Blumenfeld, 2006). Thus, this approach emphasizes the importance of cooperation, problem-solving, and reflection. Furthermore, digital technology can be applied to support Reflection and Collaboration by facilitating reflective discussions among students, providing direct feedback from teachers, and documenting students' thought processes through learning journals or assignment vlogs. Halverson and Graham (2019) highlight that student engagement in blended learning can be enhanced through digital strategies designed for active and reflective learning.

Authentic and reflective assessment applied in the Project-Based Learning model does not rely on rote memorization exams. Assessment is conducted using digital portfolios, project presentations, reflective journals, and Industry Work Practice (PRAKERIN) reports based on analysis and solutions. This authentic assessment encourages students not only to master the material but also to apply it in real-world contexts.

To clarify the integration between the deep learning approach and vocational pedagogical strategies in SMK, the following table summarizes the linkage between deep learning principles and relevant pedagogical strategies.

Table 2. Integration of Deep Learning Principles with Learning Strategies in Vocational Schools

Deep Learning Principles	Learning strategies	Application Description
Mindful Learning	Journal-based reflection and learning vlog	Increasing students' self-awareness in the learning process and work practice
Meaningful Learning	Project-Based Learning, Problem-Based Learning	Relating knowledge to real world and industry contexts
Joyful Learning	Game-based learning, creative teamwork	Increase learning motivation, collaboration, and positive emotions in learning

Table 2 shows how the three main principles of deep learning are implemented in learning strategies that are in accordance with the characteristics of vocational schools. Reflection, real-world contexts, and positive emotions are the foundations of a transformative approach.

In addition to learning strategies, the deep learning approach in vocational schools also requires an appropriate assessment system. The following is a table of assessments that support the achievement of deep learning and vocational skills.

Table 3. Types of Authentic Assessment for Deep Learning in Vocational Schools

Type of Assessment	Purpose of Assessment	Implementation Example
Digital Portfolio	Assess the learning process and outcomes comprehensively	Project documentation, written reflections, practice journals
Project Presentation	Train communication, analysis, and synthesis of conceptual understanding	Industry case-based solution presentations
Reflective Journal	Measure self-awareness, critical reflection, and meaningful learning	Student weekly notes on learning process
Internship Report	Connect industrial practice with theory and self-evaluation	Reports based on 21st century skills rubric

B. Development of Deep Learning in the Era of Global Computing

The implementation of deep learning in Indonesian education cannot run effectively without strengthening the capacity of human resources, especially teachers and education personnel. Teachers act as the main facilitators in creating meaningful, mindful, and joyful learning experiences, so they need to be supported by strong pedagogical, social-emotional, and reflective competencies. According to the Ministry of Education and Culture (2003), one of the keys to the successful implementation of the Curriculum is the ability of teachers to manage flexible and student-centered learning. Therefore, the development of GTK HR must include the right layered strategy.

Training and strengthening of transformational pedagogical competencies are essential in preparing teachers to face the challenges of 21st century education. Teachers need to be equipped with an active, reflective, and differentiated learning approach, which is in line with the principles of deep learning. Research shows that transformative learning that integrates flexible, collaborative, and context-based approaches and individual student needs can increase engagement and deep understanding (Gao & Lu, 2025). Training programs can include: (1) Project-Based and Problem-Based Learning, (2) Contextual and collaborative learning design, and (3) Techniques for building emotional involvement and student reflection in the learning process.

Strengthening social-emotional and mindfulness competencies for GTK is very important in building a positive and sustainable learning culture. To implement mindful learning, teachers must first be able to manage themselves emotionally and mentally. Various studies have shown that training in stress management, self-awareness, and emotional intelligence can improve teacher well-being, encourage empathy, and strengthen social relationships in the educational environment (Pandey, 2025; Shrestha et al., 2025).

Furthermore, the formation of Professional Learning Communities (PLC) is an effective strategy in developing teacher competencies continuously. Professional development does not only occur through formal

training, but also through peer learning communities that encourage joint reflection, collaborative pedagogical experiments, and the exchange of learning innovations. Research shows that PLCs can improve the quality of teaching through reflective practice, mutual trust between teachers, and a culture of sharing that supports meaningful and enjoyable learning innovations (Klaassen et al., 2025; Stare & Klun, 2024).

To strengthen understanding of the dimensions of teacher development in the context of deep learning, the following is a teacher competency development strategy that supports the implementation of this approach

Table 4. Teacher Competency Development Strategies in Deep Learning

Competency Aspects	Strengthening Strategy	Information
Pedagogical Competence	PjBL training, contextual learning design	Strengthening the ability to design problem-based and project-based learning
Social-Emotional Competence	Mindfulness workshop, stress management	Supporting conscious learning, empathy, and positive relationships with students
Educational Technology Competence	Blended learning training, online assessment	Increasing the integration of technology in reflective learning and assessment
Professional Community	Professional Learning Communities (PLC)	Facilitating the exchange of good practices and collaborative reflection between teachers

Teacher professional development must touch the pedagogical, emotional, and technological domains in a balanced way. This layered strategy will strengthen the ecosystem of deep and sustainable learning in vocational schools. Utilization of digital technology in the development of deep learning in Vocational High Schools (SMK) is an urgent need in the era of global computing. Integration of technology such as digital simulations, online project-based learning, and the use of digital portfolios not only improves students' technical skills but also supports the development of reflective, collaborative, and contextual competencies that are at the core of the deep learning approach. Research by Subiyantoro and Musa (2024) emphasized that teacher readiness in digital literacy and infrastructure support greatly determine the effectiveness of implementing technology-based deep learning strategies in vocational schools. Meanwhile, Farell et al. (2024) emphasized that digital technology can expand learning spaces and strengthen connectivity between schools and industry through the use of data, interactive visualizations, and real-time tracking of student competencies. This is because the culture of literacy has been increasingly abandoned by the younger generation of Indonesia, along with the development of knowledge and technology, especially in the digital field (Ifrida et al., 2023; Kurniawan et al., 2019; Wardhani et al., 2022).

The use of digital technology in vocational schools is not only as a tool, but also as a catalyst for learning transformation. To realize meaningful and adaptive deep learning, strengthening teacher competence in utilizing technology must be a priority, including through curriculum digitalization training, blended learning, and online platform-based assessments. The government, educational units, and industry need to work together to build a digital learning ecosystem that is inclusive, sustainable, and in line with the needs of the future world of work.

4. Conclusion

The deep learning approach in vocational education, especially in Vocational High Schools (SMK), has proven to be relevant and strategic in responding to the demands of 21st century competencies and the challenges of the digital era. The application of the principles of mindful, meaningful, and joyful learning can encourage the creation of a holistic, reflective, and contextual learning experience. Learning strategies such as Project-Based Learning, digital reflection, and collaboration between subjects support a deeper integration of theory and practice. In addition, an authentic assessment system based on portfolios, project presentations, and reflective journals has proven to be more effective in measuring students' applicative competencies than conventional assessments. Strengthening the implementation of deep learning also requires comprehensive development of teacher competencies. Transformative pedagogical training, strengthening social-emotional capacity, and the formation of Professional Learning Communities are important components in creating a sustainable learning culture. Furthermore, the use of digital technology is not only as a tool, but also as a catalyst for transformative and adaptive learning to industry needs. The strategy for developing deep learning in vocational schools is not only an innovative alternative, but is an urgent need in reorienting vocational education to be more responsive to changes in technology and the dynamics of the world of work. The practical implications of these findings can form the basis for the development of vocational education policies, teacher training, and curriculum design that are more inclusive, reflective, and sustainable..

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