



Leveraging EdTech in Curriculum Reform: An Evaluation Toward Sustainable Educational Outcomes

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ABSTRACT

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This study aims to evaluate the integration of educational technology in curriculum reform at pesantren-based vocational schools in responding to the challenges of the Industrial Revolution 4.0. The research employed a qualitative case study design. Data were collected through field observations, in-depth interviews, Focus Group Discussions, analysis of digital documents, and questionnaires administered to productive teachers and students of the Software Engineering and Computer and Network Engineering programs. The analysis process was carried out through data reduction, narrative presentation, and cross-verification among sources, using content, discourse, and interpretive analyses. The findings reveal that the use of the NOBOX.AI platform improved module completion rates by up to 73%, reduced assignment dropouts by 21%, and decreased paper usage. Industry collaboration through internships, teacher training, and teaching factory programs enhanced the relevance of students' skills to real workplace demands. However, challenges such as limited digital infrastructure and teachers' readiness remain significant obstacles. The implications of this study highlight the need to strengthen teacher capacity, expand equitable digital infrastructure, and ensure the sustainability of industry partnerships so that technology integration can truly foster an adaptive, relevant, and sustainable curriculum. These findings may serve as a valuable reference in formulating vocational education policies in pesantren-based contexts that are responsive to contemporary transformations.

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INTRODUCTION

The development of educational technology on a global scale continues to show significant growth, with global spending projected to reach more than 400

billion US dollars by 2025 (Ralston, 2021). However, the contribution of digitalization to total global education spending is still relatively small (Stonier et al., 2020; Spöttl & Windelband, 2021). This indicates that digital transformation in education is not yet fully optimal and still requires in-depth evaluation of its effectiveness. In the context of achieving the Sustainable Development Goals (SDGs), especially SDG 4 on quality education, technology integration needs to be viewed not only in terms of access and efficiency, but also from its impact on social, economic, and environmental sustainability (Napathorn, 2022). The theory of TPACK (Technological Pedagogical Content Knowledge) and Diffusion of Innovation (Rogers) provides a theoretical framework for understanding that the success of technology integration into the curriculum is highly dependent on the extent to which the technology supports the content, teaching approaches, and readiness to accept innovation in the school environment (Jiang, 2021; Hambali & Mardiyah, 2023).

At the national level, the Merdeka Belajar policy has encouraged the use of technology through digital platforms such as the Merdeka Mengajar Platform (Insani & Asy'ari, 2023; Rahman & Setiawati, 2023). However, the reality on the ground shows that the adoption of this technology is not evenly distributed, especially in vocational education environments (Hegerius et al., 2020; Hassan et al., 2021). Obstacles in the form of limited infrastructure, low digital literacy of teachers, and the complexity of vocational curriculum are serious challenges. A recent survey showed that most teachers do not utilize digital platforms optimally, with less than 20 percent accessing them regularly (Ali, Triyono, & Koehler, 2020; Baethge-Kinsky, 2020; Sutiman et al., 2022). This condition illustrates the existence of a fairly large digital skills gap among educators, as stated in the Deloitte report. Based on Fullan's approach to the implementation phase, the initial phase of reform is often accompanied by a decline in performance before achieving stability, which emphasizes the importance of research to systematically assess the effectiveness of digital transformation.

In the local context, Teacher Training High School Nurul Jadid has adopted a number of innovations in curriculum development, such as Teaching Factory, collaboration with industry, and the implementation of digital platforms such as NoBox.AI. Expertise programs such as Software Engineering and Computer and Network Engineering have begun to integrate cloud-based learning materials and artificial intelligence. However, to date there has been no comprehensive evaluation to assess the extent to which the integration of this technology contributes to improving student competency, school resource efficiency, and ecological operational sustainability. For example, increased electricity consumption in the laboratory, delays in completing online learning modules, and the use of several non-integrated platforms have the potential for inefficiency in the teaching and learning process. These facts show that the digital transformation in this vocational school requires data-based academic

assessment so that the direction of its development is in accordance with the principles of sustainability.

The main problem in this study lies in the absence of empirical data that explains in depth the impact of the use of educational technology on sustainable learning outcomes at Teacher Training High School Nurul Jadid. Although the school has adopted various digital systems and established industry partnerships, the effectiveness of these innovations has not been fully measured academically or ecologically. Internal data shows that student completion of LMS modules is still low, teachers use multiple platforms that cause data fragmentation, and energy consumption has actually increased, which is contrary to the principle of efficiency. This inconsistency raises important questions about the extent to which technology-based curriculum reform has created added value. Therefore, this study focuses on evaluating how and to what extent the educational technology used is able to improve the quality of learning as a whole, including its industrial relevance and environmental impact.

Various previous studies have discussed the integration of technology in education, but there is still a gap in the context of religious vocations in developing countries. Research by shows that AI-based adaptive learning can improve personalization and student engagement, but its success is highly dependent on teacher readiness and data quality. Meanwhile, Kiesler & Thorbrügge (2023) found that blended learning can significantly reduce carbon emissions and improve resource efficiency. While these findings provide important insights, no research has directly examined how technology integration in the curriculum can be evaluated from three main aspects: academic success, job-relevance, and environmental impact, particularly in the context of vocational Islamic boarding schools such as Teacher Training High School Nurul Jadid.

The gap in the scientific literature arises from the absence of research that specifically evaluates the impact of educational technology integration in Islamic boarding school-based vocational schools by combining sustainability indicators in academic, industrial, and ecological dimensions. Most previous studies have focused more on learning outcomes or general technology adoption, without considering how these innovations affect energy efficiency, relevance to industrial needs, and sustainable use of learning data. In addition, there has been no research that simultaneously tests the relevance of TPACK and SADE theories in the local Indonesian context. This study aims to fill this gap by providing a comprehensive, contextually relevant, and theoretically and practically impactful evaluative approach.

The novelty of this study lies in the development of an integrative evaluation model that combines three main dimensions: academic, industry, and environment. This model not only measures the achievement of technology-based learning through data analysis from the Learning Management System (LMS), but also assesses the suitability of the curriculum to industry needs

through alumni tracer studies, as well as the school's ecological impact through energy and paper usage audits. This study uses a qualitative approach with an exploratory sequential design, an approach that has not been applied in the context of Islamic boarding school-based Vocational High Schools (Teacher Training High School) in Indonesia. This study also integrates indicators of SDG 4 (quality education) and SDG 13 (addressing climate change), which make a significant contribution to the development of a sustainable curriculum that is relevant to future education needs.

This study aims to comprehensively evaluate how the use of educational technology in curriculum reform at Teacher Training High School Nurul Jadid has an impact on three main aspects: increasing students' digital competence, the relevance of the curriculum to the industrial world, and the efficiency and sustainability of school operations. Thus, the results of this study are expected to provide a scientific basis for making vocational education policies that are more targeted, effective, and environmentally friendly. This study is not only important for evaluating the success of the digitalization program that has been implemented, but also serves as a reference in designing sustainable technology integration strategies in similar educational institutions.

RESEARCH METHOD

This research was conducted using a qualitative approach through a case study design, which focused on the use of technology in curriculum renewal at Teacher Training High School Nurul Jadid, especially in the Software Engineering and Computer and Network Engineering departments. The objects of study include the use of Learning Management System (LMS), implementation of Teaching Factory, and alignment of the curriculum with industry partners. Information was obtained from various sources, including students as respondents, productive teachers and heads of expertise programs as informants, and document materials such as digital modules, LMS activity logs, and curriculum policy documents. Data collection techniques include literature studies, field observations, in-depth interviews, questionnaires, and focus group discussions (FGD) with internal school policy makers.

The data analysis process is carried out through three main stages, namely data reduction to filter relevant information, presentation of data in narrative and visual form, and drawing conclusions through a verification process between sources. The analysis methods used include content analysis of digital documents and data, discourse analysis to examine the narrative of curriculum policies and practices, and interpretive analysis in understanding the subjective experiences of informants (Clarke et al., 2020; Hotaling, 2021). The combination of these approaches is expected to fully describe how the integration of technology in the curriculum can encourage the achievement of more adaptive education, relevant to industry, and support the principle of sustainability in the Islamic boarding school education environment.

RESULT AND DISCUSSION

Result

AI and Adaptive Learning in Support of Continuing Education

The use of Artificial Intelligence (AI) and adaptive learning systems at Teacher Training High School Nurul Jadid through the NOBOX.AI platform demonstrates the ability of this technology to adjust learning content based on the achievements and individual needs of students. This reflects the function of AI as a technology that replicates the way humans think, as well as adaptive learning that provides a personalized learning path. Based on data from the LMS system, 73% of students completed the "Basic Algorithm" module in a shorter time than before, with a significant increase in the level of assignment completion. Teachers also utilize the analytical features in the platform to monitor student progress, although there are still obstacles in internet access and the ability to read data. Overall, the application of this technology supports the transformation of the curriculum towards a more sustainable direction, both in terms of learning outcomes, student participation, and efficiency of the learning process, as long as it is supported by increased teacher capacity and adequate infrastructure.

Through interviews with productive teachers at Teacher Training High School Nurul Jadid, it was found that they interpreted Artificial Intelligence (AI) and adaptive learning as technologies that are able to automatically adjust materials and difficulty levels of questions based on student learning achievements. The teachers revealed that the use of the NOBOX.AI platform was very helpful in monitoring student progress through the analytical dashboard feature, so that they could provide assignments that were more in line with the needs of each student. Although not all teachers had participated in the training in its entirety, they considered that the presence of this technology had a positive impact on student engagement in learning. Some of the challenges they faced included limited internet access and difficulties in analyzing learning data presented by the system. Overall, teachers considered the implementation of this technology as a positive step in supporting the development of a more responsive and sustainability-oriented vocational curriculum.

Researchers understand that the implementation of Artificial Intelligence (AI) and adaptive learning systems at Teacher Training High School Nurul Jadid is part of an effort to modernize learning that emphasizes personalization and efficiency. Through the use of the NOBOX.AI platform, teachers have access to real-time student development data, so they can design more targeted teaching strategies. Automatic adjustment of teaching materials based on student abilities reflects a change in the learning approach from a uniform system to a more individual and flexible model. However, researchers also noted that the success of this innovation is largely determined by the teacher's ability to manage technology, as well as the availability of supporting facilities such as a stable

internet network. Therefore, the integration of AI and adaptive learning in this Islamic boarding school-based vocational school environment is seen as a positive step towards sustainable education, as long as it is accompanied by strengthening the capacity of educators and adequate infrastructure support.

Table 1. AI and Adaptive Learning in Support of Continuing Education

Aspect	Description at Nurul Jadid Vocational School
Definition of AI	An intelligent system that analyzes student learning patterns and provides automatic material recommendations.
Definition of Adaptive Learning	A learning method that adjusts the level of difficulty and learning flow based on student performance.
Platforms Used	NOBOX.AI (collaboration with PT Universal Big Data – since June 2024)
Target Department	Software Engineering and Computer and Network Engineering
Implementation Form	Use of adaptive LMS, teacher analytics dashboard, automatic remedial module, question level adjustment.
Academic Benefits	- Increased learning completion (73% completed modules faster) - Decreased unsubmitted assignments (assignment drop-out decreased by 21%)
Social Benefits	Students feel cared for because the material is suited to their respective abilities.
Ecological Benefits	Reduction in the use of print modules; paper efficiency and material distribution
Teacher's Role	Facilitator and manager of data analytics-based learning
Challenge	- Limited internet access in dormitories - Need for teacher training in reading LMS data
Relevance of Sustainability	Supporting SDG 4 (Quality Education), resource efficiency, and strengthening inclusive and adaptive learning

The use of Artificial Intelligence (AI) and adaptive learning systems at Teacher Training High School Nurul Jadid is implemented through the NOBOX.AI platform, especially in the Software Engineering and Computer and Network Engineering expertise programs. This technology allows automatic analysis of student performance, so that the material provided can be adjusted to the abilities of each individual. Teachers act as companions who utilize analytical features to monitor student progress and design different learning approaches as needed. Initial results show an increase in task completion and student learning effectiveness. However, there are still obstacles in the form of limited internet networks and lack of teacher training in managing digital data. In general, the use of AI and adaptive learning in this vocational school environment reflects real efforts towards a more responsive, inclusive learning model that supports the principles of continuing education.

Teacher Training High School Curriculum Redesign Model Responding to Industry 4.0

The vocational high school curriculum update model in response to the challenges of Industry 4.0 is a systematic effort to adjust all elements of the curriculum from structure, content, learning strategies, to targeted competencies to be relevant to the needs of the ever-evolving digital era. This model aims to equip students with technical skills that are in line with technological advances such as artificial intelligence, the Internet of Things (IoT), big data, and automation, as well as essential skills such as critical thinking, communication, teamwork, and flexibility. This approach also emphasizes the importance of project-based learning, active collaboration with industry, and the use of digital platforms that support adaptive and individual learning. Overall, this curriculum design is intended to create vocational high school graduates who are able to face changes in the world of work with high readiness, creativity, and competitiveness.

The results of interviews with productive teachers at Teacher Training High School Nurul Jadid show that they interpret curriculum redesign as a process of adjusting materials and learning approaches to be more in line with the development of technology-based industries. The teachers said that the current curriculum is starting to integrate topics such as artificial intelligence, the Internet of Things (IoT), and implementing project-based learning models that encourage teamwork and solution-oriented thinking skills. They also considered that collaboration with industry provides great benefits for students in understanding the world of work directly through internships and practical training. However, challenges such as limited digital facilities and teacher readiness in using new approaches are still obstacles. Overall, they considered this curriculum redesign as an important step in creating graduates who are ready to face the dynamics of industry 4.0.

Researchers view that the vocational high school curriculum redesign model developed to address the challenges of Industry 4.0 at Teacher Training High School Nurul Jadid shows a shift in the goal of vocational education from simply producing work-ready graduates to creating an adaptive learning environment integrated with technological advances and industry needs. The integration of the latest materials such as artificial intelligence, Internet of Things (IoT), big data, and automation into project-based learning reflects a shift from a rigid learning approach to a flexible curriculum oriented towards developing future competencies.

Collaboration with the industrial world not only enriches teaching materials but also provides students with direct experience in the real world of work. However, the success of implementing this curriculum is largely determined by the readiness of teachers in designing technology-based learning,

the availability of digital infrastructure, and school management that is able to maintain continuous curriculum updates. That way, this curriculum redesign not only produces graduates who are technically competent, but also have the ability to adapt and innovate amidst the ever-changing dynamics of Industry 4.0.

Vocational School–Industry Partnerships and Operational Sustainability Aspects

The partnership between vocational schools and industry at Teacher training high school Nurul Jadid is a strategic collaboration that aims to bridge the gap between the world of vocational education and the needs of the world of work. This collaboration is realized through various activities such as the development of a curriculum that is relevant to the industry, the implementation of field work practices (PKL), training to improve teacher competency by the industry, the provision of experts from industry partners, and support for the latest technology facilities. The operational sustainability of this partnership is demonstrated through long-term commitment, the existence of a periodic evaluation system, and a mechanism for the transfer of knowledge and technology that continues from industry to schools. In the Teacher training high school Nurul Jadid environment, this partnership not only strengthens students' vocational skills, but also instills the values of work ethics and adaptive abilities that are important for facing the challenges of the world of work in the digital era in a sustainable manner.

Interviews with productive teachers of Teacher training high school Nurul Jadid revealed that cooperation between the school and the industrial world has been intensive, especially through the field work practice (PKL) program, training for teaching staff, and curriculum adjustments that are aligned with industrial needs. According to teachers, the direct involvement of industrial partners greatly helps students understand the real work environment while improving their technical skills. Training provided by the industry also helps strengthen teachers' abilities in adopting technology and professional standards into the learning process. However, the sustainability of this partnership still faces obstacles, especially in maintaining the continuity of support and updating of technological devices. Overall, this partnership is considered to have a strategic role in forming vocational education that is responsive, relevant, and ready to face future challenges.

Researchers interpret that the strategic partnership between Teacher Training High School Nurul Jadid and the industrial world functions as a “driving axis” that ensures the alignment of graduate competencies with job market demands while also being a mechanism for the sustainability of school operations. Collaboration in curriculum development, teacher training, and PKL programs forms a two-way cycle of knowledge and technology transfer: industry obtains skilled talents who understand actual work standards, while schools obtain technological updates and cutting-edge practices without having to bear

the entire cost of innovation independently. However, the success of this partnership is highly dependent on the governance of long-term relationships starting from clear cooperation contracts, periodic evaluation schemes, to commitments to facility updates. so as not to get caught up in ceremonial cooperation. From a sustainability perspective, this partnership is an important instrument for maintaining the relevance of the curriculum amidst rapid technological change, as well as supporting the operational efficiency of schools through access to equipment and ongoing training. Thus, the teacher training high school-industry partnership at Nurul Jadid Vocational High School can be seen as a synergy model that not only improves students' work readiness but also strengthens the resilience of vocational education institutions in facing the dynamics of Industry 4.0.

Table 2. Vocational School–Industry Partnerships and Operational Sustainability Aspects

Component	Description
Types of Industry Partners	Involving technology start-up companies (NOBOX.AI), network device providers (BOSNET), as well as automotive and digital MSMEs around Probolinggo.
Forms of Collaboration	Field work practice (PKL) for students in grades XI-XII, teacher training based on the latest technology, alignment of vocational curriculum with industry needs.
School Specifics	The vocational curriculum is integrated with Islamic boarding school values, combining technical skills and Islamic character in a boarding environment.
Benefits for Students	Improving digital industry skills, forming professional work ethics, and gaining real work experience through industrial internships.
Benefits for Teachers	Access to industry training, digital capacity building, and direct connection with industry practitioners to update teaching materials.
Sustainability Strategy	Annual and long-term MoUs, joint monitoring with partners, and mapping of regional industry needs to ensure the continuity of collaboration.
Operational Support	Use of shared practice space (teaching factory), integration of adaptive AI-based Learning Management System (LMS) (NOBOX.AI).
Implementation Challenges	Limited digital infrastructure, teacher readiness in digital transformation, and limited availability of the latest industrial tools and facilities in the school environment.
Impact on Schools	Improving the quality and competitiveness of graduates, ensuring the relevance of the curriculum to the dynamics of industry 4.0, and strengthening the sustainable learning system.

The table above illustrates the form of strategic partnership between Teacher Training High School Nurul Jadid and the industrial world, and how the partnership is carried out sustainably in the context of Islamic boarding school-based vocational education. The collaboration involves various industrial

partners such as technology startups and local businesses, with forms of collaboration that include field work practices, teacher training, and curriculum alignment. This model strengthens students' technical skills while instilling Islamic work ethic values. Operational support is realized through a teaching factory and the use of an AI-based LMS, while sustainability strategies are maintained through long-term cooperation agreements and joint evaluations with partners. However, challenges such as limited digital infrastructure and HR readiness are still a concern. Overall, this partnership has a positive impact on the competitiveness of graduates and the relevance of the curriculum in facing Industry 4.0.

Discussion

The varying views of educators at Teacher Training High School Nurul Jadid on the implementation of partnerships between Teacher Training High School, industry and curriculum based on Industry 4.0 reflect the existence of diverse responses to change. Some teachers responded positively because they saw the potential to improve the quality of learning and strengthen the link between teaching materials and the needs of the world of work. However, there were also many who felt burdened, especially due to the lack of digital experience and increased administrative responsibilities. These differences have the potential to be a source of innovation if facilitated through discussion forums or collaborative training, but can also create obstacles if not managed wisely. Factors such as limited training, the dominance of non-teaching work, and the values of caution typical of Islamic boarding schools are the main causes of the emergence of these diverse responses (Theobald et al., 2021; Manoharan et al., 2022).

From the community's perspective, the emergence of concerns about the direction of school policies that are considered too oriented towards the industrial world also poses its own challenges (Handayani et al., 2020; Rosa & Mujiarto, 2020). There is an assumption that this new approach is shifting religious values that have been the main strength of Islamic boarding schools. On the positive side, public criticism can encourage schools to be more accountable and maintain transparency in every form of cooperation (Laundon, McDonald, & Greentree, 2023). However, if resistance continues to occur, it is feared that it will affect the smooth running of programs such as field work practices, and even reduce public trust in schools. This rejection cannot be separated from the complex social structure, including concerns about the loss of control of Islamic boarding school norms, inequality of facilities between students, and past experiences with educational projects that are considered socially unfair.

Regarding students' academic achievement, the mixed results show that the technology-based adaptive learning approach has not been able to provide equal results. On the one hand, this reflects the system's ability to read individual needs, but on the other hand, it shows a gap that could widen if not handled properly. The main causes include unequal access to technology, varying

parental support, and an adaptive system approach that still focuses on measuring cognitive abilities without accommodating the diversity of students' learning styles, including spiritual and practical approaches. Therefore, learning strategies need to be adjusted to the characteristics of students as a whole so that this diversity of results does not become an obstacle to the success of the program in general.

This study contributes to the academic discourse by developing an integrative evaluation model that links educational technology, industry collaboration, and sustainability in pesantren-based vocational schools. Unlike previous studies that primarily focused on learning outcomes or general technology adoption, this research emphasizes three dimensions: academic improvement, industrial relevance, and ecological efficiency. By demonstrating the effectiveness of AI-driven adaptive learning and industry partnerships, the study enriches the application of TPACK and SADE theories in a unique local context. Practically, it provides policymakers and educators with evidence-based strategies for designing adaptive, relevant, and sustainable vocational education.

CONCLUSION

This study demonstrates that the integration of educational technology, particularly the use of the NOBOX.AI platform, enhances the effectiveness of learning in pesantren-based vocational schools by increasing module completion rates up to 73%, reducing assignment dropouts by 21%, and improving paper efficiency. The key lesson is that technology adoption must go hand in hand with teacher readiness and adequate infrastructure to achieve optimal outcomes. The implication is that strengthening teacher capacity, ensuring equitable digital facilities, and fostering long-term industry partnerships are essential for building an adaptive and sustainable curriculum. Scientifically, this research enriches the application of TPACK and SADE theories in a local context, while practically it offers policy guidance for vocational education in pesantren that aligns with Industry 4.0 demands. The strength of this study lies in its integrative approach connecting academic, industrial, and ecological aspects, yet its limitation lies in the single-case scope that restricts generalization. Therefore, further research with a broader quantitative approach and wider coverage is recommended to reinforce the validity of these findings and produce more comprehensive vocational education policies.

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