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Research paper

Strategies for Technology Integration in Vocational High Schools: Enhancing Teaching Quality and Student Engagement in the Digital Era

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ABSTRACT

Background: Fundamentally, many vocational schools remain unprepared for technological advancements, with limited infrastructure and varying levels of digital skills among their teachers. Therefore, understanding these challenges and identifying effective strategies for technology integration is crucial, particularly in the context of vocational schools in Indonesia.
Methods: This study used a quantitative approach. Data were collected from vocational schoolteachers specializing in construction and building technology in Yogyakarta. The analysis focused on identifying existing challenges, evaluating current technology utilization, and exploring teachers' readiness to adopt innovative digital tools in the learning process.
Results: The findings indicate that most teachers consider current technology integration efforts to be adequate; however, technology infrastructure remains limited, digital competency is unequal, and resistance to pedagogical change is present. Teachers recognize that technology has significant potential to make learning more interactive and engaging, and many students incorporate digital tools into their assignments and projects. However, overall implementation is inconsistent and requires further support.
Conclusion: Strengthening teacher training in innovative digital practices, enhancing technological infrastructure, and fostering supportive policies from school management and government are essential steps. These measures are expected to increase the competitiveness of SMK graduates in the labor market while promoting a more dynamic and interactive learning environment.

INTRODUCTION

The rapid advancements in technology have significantly transformed various sectors, including education (Shaheen & Shaikh, 2024) (Gowher, 2023). Vocational high schools (SMK) in Indonesia, tasked with preparing students for the labor market, are no exception. Integrating technology into their curricula has become an urgent necessity to enhance teaching quality and student engagement, particularly in the context of the digital era(Federal Ministry of Education and Research, 2021)(OECD, 2023) (UNESCO, 2022) (Panakaje et al., 2024) (Firdaus et al., 2023). Previous studies emphasize the importance of technology in making learning more interactive and aligned with industry demands(Grech, 2025) (Dito & Pujiastuti, 2021). However, despite the recognized potential, several challenges hinder effective integration, including limited infrastructure, uneven digital literacy among educators, and resistance to change (Revaldhi et al., 2025). Vocational education plays a pivotal role in equipping students with practical skills that directly align with industry needs (Rosina et al., 2021) (Mahmudah & Santosa, 2021). This aligns with Indonesia's broader agenda to improve workforce readiness in a highly competitive global market. However, the transition to a technology-driven curriculum presents multifaceted challenges. For instance, while some SMKs have embraced digital tools, others lag due to inadequate resources or a lack of trained personnel (Sanjana, 2022). This disparity highlights the urgency of addressing these barriers to ensure equitable and effective technology adoption across all SMKs.

The importance of technology integration in education is widely acknowledged. Studies have shown that technology can improve student learning outcomes, foster critical thinking, and increase engagement through interactive and multimedia-rich content (Soufghalem, 2024)(OECD, 2025)(Starkey, 2022). For vocational schools, technology also bridges the gap between classroom learning and real-world applications. For example, simulation software, virtual reality, and industry-specific tools enable students to gain hands-on experience in a controlled environment, better preparing them for their future careers. Despite these advantages, research indicates persistent challenges. Infrastructure limitations remain a critical issue, particularly in rural or underfunded schools. Uneven access to digital devices, unreliable internet connections, and outdated facilities are common obstacles(Hamed et al., 2022). Moreover, many educators face difficulties adapting to new technologies due to insufficient training or resistance to change. This resistance often stems from a lack of confidence in using digital tools or a perceived threat to traditional teaching methods(Mahbob et al., 2024).

Existing literature provides valuable insights but leaves significant gaps, particularly regarding SMKs in Indonesia. While general studies on educational technology are abundant, research specifically tailored to vocational schools and their unique needs is limited. This research seeks to bridge this gap by focusing on SMKs specializing in construction and building technology, a field that is both highly technical and integral to Indonesia's infrastructure development goals.

Therefore, this study aims to move beyond theoretical discussions by providing empirically grounded and actionable strategies for technology integration in vocational high schools. Specifically, the objectives of this research are: (1) to analyze the current level of technology integration in vocational high schools specializing in construction and building technology; (2) to identify key barriers faced by teachers and students in implementing technology-enhanced learning; (3) to examine the impact of technology integration on teaching quality and student engagement; and (4) to propose practical, context-specific strategies for effective and sustainable technology integration in vocational education. By focusing on both challenges and implementable solutions, this study seeks to provide evidence-based recommendations for educators, school leaders, and policymakers to enhance digital transformation in vocational high schools.

The novelty of this study lies in its dual focus on challenges and solutions. By examining the current state of technology integration in SMKs, it aims to identify specific barriers faced by educators and students. These include not only technical issues, such as inadequate infrastructure, but also cultural and organizational challenges, such as resistance to change and insufficient support from school management. The study also seeks to propose innovative, actionable strategies that address these barriers, ensuring that technology integration is both effective and sustainable.

Preliminary findings reveal a mixed landscape. While most respondents acknowledge the potential of technology to enhance teaching and learning, they also highlight significant barriers. Limited infrastructure, such as inadequate computer labs and unreliable internet access, is a common concern(Liso & Mbukanma, 2024). Additionally, teachers report varying levels of digital literacy, with some feeling confident in using technology while others struggle to integrate even basic tools into their lessons. Resistance to change—both among educators and within the broader school culture—emerges as another critical issue. One of the study's key contributions is its emphasis on practical solutions. Based on the survey data, several recommendations are proposed. First, enhancing teacher training programs is crucial(Dange & Siddarraju, 2020). These programs should not only focus on technical skills but also address pedagogical strategies for integrating technology into vocational education. Workshops, peer mentoring, and online courses can provide teachers with the tools and confidence needed to embrace digital learning.

Second, improving technological infrastructure is essential(Ergüzen et al., 2021)(Zhu et al., 2019)(Purnamasari et al., 2025). This includes upgrading computer labs, ensuring reliable internet access, and providing schools with industry-specific software and tools. Partnerships with private sector companies and government agencies could help fund these initiatives, ensuring that all SMKs have access to the resources they need. Third, fostering a supportive culture within schools is critical. This involves encouraging collaboration among teachers, promoting a growth mindset, and recognizing the efforts of educators who adopt innovative teaching methods. School management plays a vital role in this process by setting clear expectations, providing ongoing support, and celebrating successes.

At the policy level, government intervention is necessary to ensure equitable access to technology across all SMKs. Policies should prioritize funding for underprivileged schools, streamline procurement processes, and establish clear guidelines for technology integration. Additionally, collaboration between the Ministry of Education and industry stakeholders can help align vocational curricula with current and future workforce needs. This study also underscores the importance of student involvement in the technology integration process. Teachers report that students are often more adept at using digital tools than their instructors, suggesting an opportunity to leverage this expertise. Encouraging students to take an active role in technology adoption—whether through peer-to-peer training, project-based learning, or student-led initiatives—can enhance their engagement and ownership of the learning process(Hardianti et al., 2024)(Balalle, 2024).

By addressing these issues, the study aims to strengthen the competitiveness of SMK graduates in the labor market. A well-integrated technology curriculum not only equips students with technical skills but also fosters critical thinking, creativity, and adaptability—qualities that are highly valued by employers. Moreover, it prepares students to navigate the challenges and opportunities of a rapidly evolving digital landscape. In conclusion, this research highlights the potential of technology to transform vocational education in Indonesia. While significant challenges remain, they are not insurmountable. By adopting a holistic approach that addresses infrastructure, training, culture, and policy, SMKs can create a dynamic and interactive learning environment that meets the demands of the digital era. The findings and recommendations of this study aim to contribute to the ongoing discourse on educational technology, offering practical insights that can inform future research, policy, and practice. Ultimately, the goal is to ensure that SMK graduates are not only workforce-ready but also equipped to thrive in an increasingly technology-driven world.

METHODS

A. Research Design

This study employed a quantitative survey design with complementary qualitative responses to explore teachers' perceptions of technology integration in vocational high schools (SMK), particularly in construction and building technology programs. The study aimed to identify the extent of technology integration in curriculum implementation, learning interactivity, and encouragement for student use of digital tools, as well as to derive practical strategies for improving teaching quality and student engagement in the digital era.

B. Population and Sample

The population consisted of vocational high school teachers specializing in construction and building technology in Yogyakarta Province. Based on data from the Regional Education Office, there were 30 teachers across 15 vocational high schools.

A purposive sampling technique was applied to select teachers who met the following criteria: (1) teaching construction-related subjects, (2) having at least one year of teaching experience, and (3) having experience using digital tools in teaching and learning activities. A total of 30 teachers from 15 vocational high schools participated in the study.

To enhance representativeness, participants were selected from schools with different geographical locations (urban and semi-urban), accreditation levels, and technological infrastructure conditions.

C. Instrument Development, Validity, and Reliability

Data was collected using a structured questionnaire developed based on a literature review and preliminary field exploration. The instrument measured teachers' perceptions of technology integration using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree).

Content validity was established through expert judgment by two specialists in educational technology and vocational education, who evaluated the relevance, clarity, and representativeness of the items. Revisions were made based on their feedback. Construct validity was examined using item–total correlation analysis, and items with correlation coefficients above 0.30 were retained.

Reliability was tested using Cronbach's alpha to assess internal consistency. The overall reliability indicates acceptable to high reliability ($\alpha > 0.70$).

D. Operational Definition of Variables

1. Dependent Variable

Teachers' perceptions of technology integration in learning were defined as teachers' evaluations of how digital technologies are incorporated into instructional practices in vocational education. This variable was operationalized through three indicators:

a. Curriculum integration, referring to the extent to which digital tools are aligned with curriculum content and learning objectives.
b. Learning interactivity refers to the use of technology to enhance student engagement and interactive learning processes.
c. Encouragement for student technology use, referring to teachers' practices in promoting students' use of digital devices for tasks, projects, and learning activities.

Each indicator was measured using multiple Likert-scale items, and mean scores were calculated for each indicator and the overall construct.

2. Independent Variables

The independent variables included:

a. Teacher digital competence, defined as teachers' ability to use digital tools for instructional purposes.
b. Technological infrastructure, defined as the availability of hardware, software, and internet connectivity.
c. Institutional support, defined as school leadership, policies, and professional development related to technology integration.

E. Research Procedure

The research procedure consisted of four stages: Stage 1: Preliminary exploration, involving document analysis and informal discussions with school administrators and teachers to identify technological conditions and contextual challenges. Stage 2: Instrument development, including expert validation and pilot testing to ensure validity and reliability. Stage 3: Data collection, in which questionnaires were distributed in both online and printed formats. Completed questionnaires were collected, coded, and entered into the dataset. Stage 4: Data analysis, involving quantitative and qualitative analysis to address the research objectives.

F. Data Analysis Technique

Quantitative data were analyzed using descriptive statistics, including mean scores and frequency distributions, to determine the level of technology integration across the three indicators. Measurement results were interpreted using the following interval criteria (Table 1).

Qualitative responses from open-ended questions were analyzed using thematic analysis to identify challenges and strategies related to technology integration. The qualitative findings were used to complement and contextualize the quantitative results.

Table 1.
Interval Criteria

Mean Score Interval	Category
1.00 – 1.80	Very Low
1.81 – 2.60	Low
2.61 – 3.40	Moderate
3.41 – 4.20	High
4.21 – 5.00	Very High

RESULTS AND DISCUSSION

The results of this study reveal important insights into the integration of technology in vocational education, specifically in construction and building technology programs. As illustrated in the figure, the majority of respondents perceive technology integration as moderately effective, but significant challenges remain in fully realizing its potential.

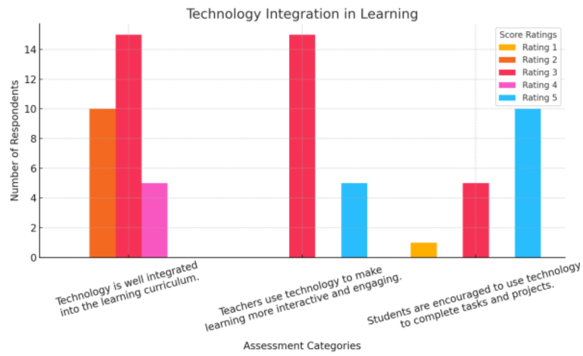

Figure 2. Technology Integration in Learning

The first assessment category, *"Technology is well integrated into the learning curriculum,"* received an average rating of 3, indicating a moderate level of technology integration across the vocational high schools studied. This rating suggests that although notable efforts have been undertaken to incorporate technology into the curriculum, the overall implementation has not yet reached an optimal or consistent standard. In many schools, teachers have begun using digital tools to support lesson delivery, such as multimedia presentations, online learning platforms, and basic subject-specific software. However, these initiatives often remain at the surface-level and do not extend into deeper pedagogical practices that fully leverage the potential of technology to enhance learning outcomes.

Teachers reported ongoing challenges in aligning technology with specific subject areas, especially within vocational fields like construction and building technology that rely heavily on hands-on, practical experience. While digital tools such as simulation software, 3D modeling applications, and virtual demonstrations can theoretically enhance student understanding, many teachers indicated that these tools are either unavailable, insufficiently supported, or too complex to integrate without proper training. As a result, technology use tends to be limited to general-purpose tools that do not fully address the technical competencies needed in vocational programs.

In rural and semi-urban schools, these difficulties are further compounded by infrastructural limitations. Several teachers highlighted the persistent issue of unreliable internet connectivity, inadequate bandwidth, and inconsistent electricity supply, which negatively impact technology-based instruction. Additionally, many schools lack sufficient devices such as computers, tablets, or projectors, resulting in shared usage that restricts student participation. This disparity creates an uneven learning experience across schools and widens the digital divide, particularly for students in remote areas who may benefit the most from technology-enabled resources.

Another concern raised by teachers relates to inconsistencies in curriculum updates and the lack of explicit guidelines for integrating digital tools into specific competency standards. Some teachers felt that curriculum revisions do not always incorporate emerging technological trends in their respective industrial fields, leading to outdated learning content. This misalignment discourages teachers from investing time in integrating technology meaningfully, as they perceive the curriculum to be insufficiently responsive to current industry needs.

To address these challenges, standardizing technology-based curriculum frameworks across vocational schools is essential. This includes clearly defining the types of digital tools and competencies expected at each grade level, as well as providing exemplar teaching materials and lesson scenarios that demonstrate effective integration. Additionally, targeted investments in technological infrastructure—particularly in underserved regions—are crucial for ensuring equitable access to digital learning resources. Enhancing teacher training programs is also necessary so that teachers feel confident and competent in utilizing technology for both theoretical and practical instruction.

By systematically addressing issues of infrastructure, curriculum alignment, and teacher readiness, vocational schools can strengthen the role of technology as an integral component of learning. Improved integration will not only support more interactive and engaging classroom experiences but also better prepare students to meet industry standards and adapt to the technological demands of the modern workforce.

In the second category, "Teachers use technology to make learning more interactive and engaging," the findings indicate a generally positive trend, as reflected in the distribution of responses in the middle to higher rating ranges, particularly ratings of 3 and 5 on the scale. This pattern suggests that many teachers recognize the valuable role of technology in enhancing instructional quality and stimulating student interest in learning activities. The responses show that teachers increasingly acknowledge how digital tools can transform traditional classroom practices into more dynamic and meaningful learning environments.

Teachers described various ways in which technology has supported interactivity in the classroom. The use of multimedia presentations, instructional videos, virtual simulations, and digital design software allows them to present complex concepts related to construction and building technology more clearly. For example, simulation-based tools enable students to visualize structural components, analyze building layouts, and explore technical processes that would be difficult to understand through conventional lecture methods alone. These tools make abstract or theoretical content more concrete, helping students develop stronger conceptual understanding. Additionally, project-based learning platforms help teachers guide students in collaborative assignments, where learners can work together online, share files, and monitor progress through digital dashboards.

Several teachers also reported that technology has improved student engagement, motivation, and participation, particularly for students who prefer visual or hands-on learning.

Interactive tools such as quizzes, digital worksheets, and animation-based explanations contribute to creating a more enjoyable learning environment. Some teachers mentioned that integrating short videos, virtual demonstrations, and augmented reality resources within lessons helped capture students' attention more effectively. These advantages highlight the increasing readiness of teachers to adopt technology when relevant tools and adequate support are available.

However, despite the overall positive trend, not all teachers reported equally positive experiences. A portion of respondents gave lower ratings, indicating that their ability to use technology for interactive learning remains limited. The primary challenges include insufficient training, limited access to appropriate software, and inadequate school hardware infrastructure. Teachers who lack the necessary skills often rely on outdated teaching approaches, such as conventional lectures or chalk-and-board explanations, which reduces the interactive potential of their lessons. In several cases, teachers noted that although digital tools are available, they are not fully utilized because teachers feel unprepared or uncertain about classroom integration strategies.

Hardware limitations, such as old computers, unstable internet connections, and the absence of licensed software for technical subjects, further hinder the use of interactive digital learning. These constraints lead to fragmented implementation, where teachers want to innovate but cannot do so consistently. As a result, the potential benefits of technology are not maximally realized for all students.

To address these limitations, targeted capacity-building programs, such as hands-on workshops and sustained professional development, are essential. Training should focus not only on basic digital skills but also on pedagogical integration strategies that help teachers align technology use with learning objectives. Schools must also allocate adequate resources to upgrade devices, ensure access to essential software, and improve internet connectivity.

By reducing these barriers, teachers can more confidently adopt technology to create interactive and engaging learning environments. Ultimately, strengthening the interactive use of technology can help bridge gaps in student comprehension, promote active participation, and contribute to improved learning outcomes in vocational education.

The final category, *"Students are encouraged to use technology to complete tasks and projects,"* received mixed responses, with teachers' ratings distributed between 3 and 5 on the scale. This variation suggests that while some teachers actively promote the use of digital tools in classroom activities, others face constraints that prevent them from doing so consistently. The distribution of responses reflects broader disparities in technology adoption practices within vocational high schools, particularly in specialized fields such as construction and building technology. This inconsistency indicates that although the potential of digital tools is widely recognized, the degree to which students are actually encouraged to use them varies significantly across schools.

Teachers who provided higher ratings (scores of 4 and 5) described several concrete examples of how technology is integrated into student tasks. They reported actively guiding learners to use software such as AutoCAD for drafting and design, 3D modeling tools for construction planning, and project management applications for coordinating group work. These digital tools are closely aligned with industry standards, making their use in classroom assignments particularly valuable. Incorporating such technologies gives students the opportunity to practice job-relevant skills, engage in more interactive and professional learning experiences, and understand how digital competencies support workplace productivity. Teachers in this group emphasized that technology-supported projects not only increase student engagement but also cultivate higher-order thinking, problem-solving abilities, and creativity—competencies essential for success in modern industries.

However, teachers who assigned lower ratings identified several critical barriers that limit students' ability to use technology effectively. One of the most prominent constraints is the limited availability of devices in many vocational schools. In some institutions, computer labs are insufficient, outdated, or unable to accommodate entire classes, forcing teachers to rotate student access or minimize technology-based tasks. Additionally, unequal distribution of digital literacy among students further complicates implementation. Teachers noted that while some students are comfortable navigating digital tools, others struggle with basic operations, slowing down the pace of learning and requiring additional instructional support.

Another significant issue raised relates to disparities in students' access to technology at home. Many learners do not possess personal computers or stable internet connections, making it difficult for them to complete digital tasks outside school hours. This digital divide results in uneven learning experiences, where students with better access can complete assignments more effectively than those without technological resources. Teachers expressed concern that these differences not only hinder academic performance but also perpetuate broader inequalities in digital readiness.

To overcome these challenges, the findings highlight the need for more structured policies and sustained funding to support technology use in vocational education. Schools require targeted investments in digital infrastructure, including updated computer laboratories, reliable internet connectivity, and adequate maintenance support. Equally important is the need for systematic training programs that equip both teachers and students with the necessary digital competencies. Providing workshops on essential software, integrating digital literacy modules into the curriculum, and offering access to shared technological resources can help narrow existing gaps.

Encouraging consistent and equitable technology use across vocational schools is essential to ensure that all students—regardless of socioeconomic background—can develop the digital skills needed in the modern workforce. Strengthening these practices will enhance students' employability, support smoother transitions into technology-driven industries, and contribute to the broader goal of preparing a competitive and future-ready vocational workforce.

The benefits of these findings are substantial. By addressing the identified challenges—such as infrastructure limitations, teacher training, and access disparities—vocational schools can improve their competitiveness and better prepare graduates for the demands of the digital workforce. These results align with previous studies emphasizing the role of technology in enhancing learning outcomes (e.g., studies on interactive learning tools and blended learning methods). However, unlike earlier research, which often focuses on general education, this study provides specific insights into vocational education, addressing the unique challenges faced by SMK programs.

This study has limitations. First, the cross-sectional design limits causal inference. Second, data were based on self-reported perceptions, which may be subject to response bias. Future studies should employ longitudinal and experimental designs.

In conclusion, while the integration of technology in vocational education shows promising results, improvements are necessary to overcome the existing barriers. By implementing targeted policies and providing additional training, schools can foster a more dynamic, interactive, and equitable learning environment that meets the demands of the digital era.

CONCLUSION

The findings of this study provide empirical evidence on the level and pattern of technology integration in vocational high schools specializing in civil engineering and building technology. The results indicate that teachers generally perceive technology integration positively, particularly in enhancing curriculum delivery, learning interactivity, and students' use of digital devices. However, the analysis also reveals significant disparities in implementation, which are strongly associated with infrastructural limitations, variations in teachers' digital competence, and the absence of consistent institutional and policy support.

Specifically, the data demonstrate that schools with better digital infrastructure and teacher training programs show higher levels of interactive learning practices and more frequent student engagement with digital tools. Conversely, schools with limited resources exhibit lower levels of integration, suggesting that technological readiness is a critical enabling factor for effective digital pedagogy in vocational civil engineering education. These findings confirm that technology integration is not solely a pedagogical issue but also a systemic challenge involving infrastructure, professional development, and governance.

From a practical perspective, the results imply that vocational civil engineering programs should prioritize the development of digital learning ecosystems, including the provision of industry-relevant software, learning management systems, and simulation tools. Teacher professional development should focus not only on technical skills but also on pedagogical strategies for integrating digital technologies into competency-based vocational curricula. Furthermore, policy frameworks at the school and governmental levels should establish clear standards, funding mechanisms, and monitoring systems to ensure equitable and sustainable technology integration across vocational institutions.

For future research, longitudinal and experimental studies are recommended to examine the causal impact of technology integration on students' technical competencies, employability skills, and learning outcomes in vocational civil engineering contexts. In addition, qualitative investigations into teachers' pedagogical decision-making and students' digital learning experiences would enrich the understanding of how technology can be optimally embedded in vocational education.

Overall, this study contributes to the growing body of knowledge on digital transformation in vocational education by providing empirical insights and actionable recommendations for improving technology integration in civil engineering vocational learning environments.

DISCLOSURE STATEMENT

The author declares that there is no potential conflict of interest regarding the research, authorship, and publication of this manuscript. All procedures, analyses, and interpretations presented in this work were conducted independently, without any financial, professional, or personal relationships that could be viewed as influencing the content or outcomes of the study. The author affirms that the research was carried out objectively and transparently, adhering to ethical standards and academic integrity.

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