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Article

Bridging Digital and Vocational Learning: The Role of AI in Enhancing Culturally Responsive TLE Instruction and Pedagogical Approaches

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Abstract

This study explores the perceptions and experiences of Technology and Livelihood Education (TLE) educators in integrating artificial intelligence (AI) tools into vocational instruction and pedagogy. Grounded in the Technological Pedagogical Content Knowledge (TPACK) framework and Rogers' Innovation Diffusion Theory, the research examines the challenges and opportunities presented by AI adoption in skill-based learning within TLE curricula. Employing a qualitative phenomenological approach, data were gathered through semi-structured interviews, focus group discussions, and document analysis, with thematic analysis used to identify key insights. Findings reveal that while TLE educators acknowledge AI's potential in enhancing instructional engagement, personalized learning, and efficiency, concerns persist regarding over-reliance on technology, access limitations, and the need for professional training. The study also highlights pedagogical shifts, including the adoption of blended learning strategies, AI-assisted assessments, and new instructional approaches that balance technological integration with hands-on practice. These results underscore the need for targeted AI training programs, infrastructure development, and institutional support to optimize AI's role in vocational education.

Keywords: *AI integration, vocational education, technology and livelihood education, personalized learning, pedagogical strategies, skill-based learning, blended learning, teacher perceptions, educational technology*

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Introduction

The rapid advancement of artificial intelligence (AI) is reshaping education across the globe, including the field of Technology and Livelihood Education (TLE), where skill-based and practical learning are essential. TLE subjects, including cookery, agriculture, entrepreneurship, ICT, and industrial arts, are uniquely positioned at the intersection of academic learning and cultural practice. These subjects aim to build technical competencies in the Philippines and embody cultural knowledge systems, livelihood traditions, and community values. AI-driven tools, such as intelligent tutoring systems, adaptive assessments, and virtual simulations, present opportunities to enhance TLE by offering personalized learning experiences, real-time feedback, and innovative ways of bridging theory with practice.

Despite its potential, the integration of AI in TLE presents significant challenges. Vocational learning requires hands-on, tactile experiences that technology cannot fully replicate. Furthermore, in culturally diverse settings such as the Philippines, TLE instruction often draws upon indigenous practices, community-based livelihood strategies, and local industry contexts, which AI platforms designed from Western models may fail to capture. Educators are therefore tasked with adopting new technologies and aligning them with their learners' cultural and contextual realities. While AI integration in education has been explored extensively in academic disciplines, limited research exists on how TLE educators perceive and adapt AI within culturally grounded, resource-constrained environments, particularly in Philippine schools.

This study seeks to fill that gap by examining TLE educators' perceptions, challenges, and adaptations in using AI for instruction. By situating AI integration within the local educational and cultural context of the Philippines, the study contributes to the discourse on AI-driven vocational education that is both pedagogically effective and culturally responsive. Integrating AI in vocational and technical education is increasingly recognized as a transformative force. Wang, Chen, and Patel (2021) highlight that AI-driven simulations allow learners to practice technical skills virtually before applying them in real-world contexts. Similarly, Jia, Zhou, and Zhang (2022) found that augmented reality and AI-powered tutoring enhance engagement, bridging the gap between abstract knowledge and practical competencies. These findings resonate with the goals of TLE, which emphasize competency-based instruction and applied learning.

AI has also been shown to support personalized learning pathways. Brown and Taylor (2022) argue that AI-powered assessments provide real-time feedback, allowing teachers to focus on higher-order tasks such as critical thinking and

creativity. Garcia and Rivera (2022) add that AI fosters competency-based progression, enabling learners to achieve industry-aligned benchmarks at their own pace. In blended learning contexts, Chen, Martinez, and Klein (2023) highlight AI's potential to integrate digital tools with traditional, hands-on training.

However, several challenges persist. Zhu, Green, and Moore (2020) caution that AI cannot fully replace vocational education's tactile, collaborative, and cultural aspects, especially in settings where practical work and local knowledge are central. Li and Zhao (2021) emphasize that the digital divide, particularly in developing countries, is unequal access to infrastructure and connectivity that limits AI adoption. Teacher readiness is another barrier: Sun, Wang, and Liu (2022) note that many educators lack adequate training in AI tools, while Meyer and Schubert (2020) stress the importance of professional development in building teachers' confidence and competence.

Educator attitudes toward AI remain complex. Sang, Rivas, and Thompson (2021) observe that some teachers fear displacement by AI, while others view it as a supportive tool. Importantly, in culturally rich contexts like the Philippines, there are concerns about cultural misalignment: many AI tools are designed with Western pedagogical assumptions, which may not reflect local practices in agriculture, trade, or entrepreneurship. This issue aligns with the call for culturally responsive pedagogy, as emphasized by Gay (2018), which highlights the importance of embedding cultural values, traditions, and knowledge systems into teaching and learning processes.

While literature establishes AI's potential in vocational education, most studies focus primarily on student outcomes such as engagement, performance, and skill acquisition, while giving limited attention to the experiences and perspectives of teachers. Moreover, much of the research is situated in technologically advanced or resource-abundant contexts, with little exploration of AI integration in settings like Philippine public schools, where infrastructural challenges, cultural diversity, and local livelihood contexts play a significant role.

The gap is even more pronounced in the case of TLE, which inherently draws from community knowledge, cultural practices, and local economies. There is little understanding of how AI can be adapted to reflect cultural relevance in skills training, or how educators navigate the balance between technology-driven instruction and culturally grounded pedagogy. Addressing this gap is crucial in ensuring that AI adoption in TLE does not perpetuate inequities or diminish cultural authenticity but enhances inclusive, context-sensitive, and future-ready education.

This study thus seeks to contribute to both theory and practice by exploring TLE educators' perceptions, challenges, and adaptations as they integrate AI into teaching,

with particular attention to cultural responsiveness and contextual realities in Philippine schools.

Research Objectives

1. To explore the perceptions and experiences of TLE educators in integrating AI tools into vocational instruction and pedagogy.
2. To examine the challenges and opportunities associated with AI adoption in enhancing skill-based learning within TLE curricula.
3. To analyze the pedagogical shifts and instructional strategies TLE teachers employ in response to AI-driven educational innovations.

Theoretical Framework

This study was anchored in two theoretical foundations. The Technological Pedagogical Content Knowledge (TPACK) Framework (Mishra & Koehler, 2006) provided insights into how educators balanced technological, pedagogical, and content knowledge when using AI in vocational instruction. It emphasized the need for teachers to develop both technical competence and effective instructional strategies. Additionally, Rogers' (2003) Innovation Diffusion Theory explained the process of AI adoption among TLE educators, highlighting factors such as perceived usefulness, ease of use, and institutional support in determining the adoption rate.

Through this conceptual framework, the study established relationships among educators' perceptions, challenges and opportunities encountered, and their pedagogical adjustments in response to AI integration. By examining these interconnections, the research provided a deeper understanding of how AI impacted TLE instruction and what measures could be taken to optimize its role in vocational education.

Research Methodology

This study employed a qualitative research design to explore the perceptions and experiences of TLE educators regarding AI integration in vocational instruction and pedagogy. A phenomenological approach was used to gain in-depth insights into how TLE teachers navigated the opportunities and challenges presented by AI-driven educational innovations. This approach was appropriate as it sought to understand the lived experiences of educators in adapting to new technologies in skill-based learning environments.

The participants of this study consisted of TLE educators from secondary schools and technical-vocational institutions who had experience integrating or exploring AI tools in their teaching. A purposive sampling technique was used to select participants based on specific criteria, including active involvement in TLE instruction, prior exposure to AI-driven tools, and willingness to participate in interviews or focus group discussions. The study included 10–15 TLE educators to ensure diverse perspectives while maintaining data saturation.

Data was collected through semi-structured interviews and focus group discussions (FGDs). Individual interviews allowed educators to share their experiences, perspectives, and reflections on AI integration in TLE instruction. Open-ended questions encouraged detailed responses. Additionally, FGDs were facilitated to promote collaborative insights and compare shared experiences among TLE educators. Document analysis was also performed, where relevant lesson plans, AI-driven instructional materials, and policies on AI integration were reviewed to support findings from the interviews and FGDs.

The collected data underwent thematic analysis, following Braun and Clarke's (2006) six-phase framework. The process began with familiarization, where transcripts were reviewed and read multiple times. Initial codes were then generated, identifying meaningful patterns and categorizing recurring themes. These codes were further analyzed to identify broader themes, such as perceived benefits, pedagogical shifts, barriers to adoption, and prospects. The identified themes were refined and validated to ensure coherence and relevance to the research objectives. Finally, findings were presented with direct participant quotes to illustrate key insights. Ethical considerations were strictly observed throughout the study. Informed consent was obtained from all participants before data collection, ensuring they knew the study's purpose and rights. Anonymity and confidentiality were maintained by using pseudonyms instead of real names. Ethical approval was secured from the Institutional Research Ethics Committee, and participants could withdraw at any stage without consequences. To ensure the study's trustworthiness, several measures were implemented. Member checking was conducted, where participants were asked to review and validate the findings. Peer debriefing was also conducted by consulting with other researchers to ensure objectivity in data analysis. Furthermore, triangulation was employed, using multiple data sources, including interviews, FGDs, and document analysis, to strengthen the credibility and reliability of the study.

Results and Findings of the Study

Perceptions and Experiences of TLE Educators in Integrating AI into Vocational Instruction and Pedagogy

Integrating Artificial Intelligence (AI) in Technology and Livelihood Education (TLE) has generated optimism and caution among educators, reflecting its dual role as an innovation and a challenge in vocational learning. Many TLE teachers view AI positively, noting its capacity to make lessons more engaging and interactive through simulations that allow students to visualize technical skills before applying them in real-world contexts. AI-powered platforms also support personalized learning by adjusting to the pace and needs of individual learners, thereby addressing diverse skill levels in the classroom. Such enthusiasm demonstrates the transformative potential of AI as a supplementary tool to traditional pedagogy, aligning well with the demands of skill-based instruction. However, despite this optimism, skepticism persists. Some educators express apprehension about over-reliance on AI, particularly its inability to fully replicate the tactile, hands-on experiences foundational to vocational training. Concerns about limited training, accessibility, and the risk of diminishing human interaction highlight the importance of balanced integration. These insights point to the need for robust implementation strategies and professional development programs that ensure AI enhances rather than replaces traditional practices, fostering an instructional model that preserves vocational education's essential cultural and practical dimensions.

Optimism Towards AI as a Teaching Aid

Many TLE educators expressed a positive outlook toward AI, emphasizing its role in enhancing lesson engagement and supporting personalized learning. AI tools have enabled teachers to provide interactive simulations, allowing students to visualize technical skills before applying them in real-world scenarios. Additionally, AI-driven learning platforms have helped students learn at their own pace, catering to different skill levels.

"AI has helped me create more engaging lesson materials, such as interactive simulations for technical skills training. It makes learning more dynamic and appealing to students."

"Integrating AI in my TLE classes has made it easier to personalize learning. Students can work at their own pace using AI-powered tutorials, which help them master skills more effectively."

The enthusiasm shown by educators suggests that AI has significant potential in vocational education, particularly in supplementing traditional teaching methods. The ability to customize learning paths through AI aligns with the needs of skill-based

instruction. However, this optimism indicates a growing expectation for continuous improvements and expanded access to AI-driven tools in TLE classrooms.

Uncertainty and Skepticism About AI in Vocational Education

Despite the optimism, some educators expressed concerns about over-reliance on AI and its limitations in practical skills training. They feared AI might diminish hands-on learning experiences, essential in vocational education. Additionally, uncertainty about properly integrating AI into their teaching has led to hesitation and resistance.

"While AI tools seem promising, I sometimes feel overwhelmed. I am unsure if I am using them correctly, and I worry that students rely too much on technology rather than hands-on practice."

"AI is useful, but I still question its reliability in practical skills training. Vocational education requires physical execution, and I fear AI might replace essential hands-on activities."

These concerns highlight the need for clear implementation strategies and professional development programs for educators. While AI is valuable, vocational education still requires a balance between digital and physical learning experiences. This skepticism indicates that AI integration should be carefully designed to complement rather than replace traditional skill-based instruction.

Challenges and Opportunities in AI Adoption for Enhancing Skill-Based Learning in TLE Curricula

Integrating Artificial Intelligence (AI) in Technology and Livelihood Education (TLE) has generated mixed but insightful perspectives among educators, reflecting optimism and skepticism toward its role in vocational learning. On one hand, many teachers view AI as a powerful teaching aid that enhances lesson engagement and supports personalized learning. AI-powered tools, such as interactive simulations and adaptive tutorials, allow students to visualize technical skills before practicing them while providing opportunities to learn at their own pace depending on their proficiency levels. These features align with TLE's learner-centered and skill-based goals, making lessons more dynamic, accessible, and responsive to individual needs. On the other hand, some educators remain cautious about over-reliance on AI and its limitations in replicating the tactile, hands-on experiences vital in vocational education. Concerns about technological reliability, insufficient training, and the possibility of diminishing physical practice highlight the uncertainty surrounding AI integration. These tensions emphasize that while AI holds great promises for

supplementing TLE instruction, its adoption must be carefully guided by balanced implementation strategies, professional development, and policies that ensure AI complements rather than replaces traditional skill-based teaching. This dual perspective underscores the importance of developing a culturally and pedagogically responsive framework for AI integration that respects vocational education's practical, contextual, and human dimensions.

Limited Access to AI Tools and Training

One of the significant barriers to AI adoption in TLE instruction is the lack of access to necessary resources and technical training. Many schools, especially rural ones, face infrastructure limitations such as unreliable internet, inadequate AI tools, and limited teacher training programs. Educators feel unprepared to fully integrate AI into their teaching due to insufficient institutional support.

"Most of us do not have proper training on AI integration. We are expected to use AI-driven tools but lack workshops or technical support."

"Some schools, especially in rural areas, have no access to AI-powered resources. The internet is slow, and we do not have enough computers, making AI integration difficult."

AI as an Opportunity for Personalized Learning and Efficiency

Despite the challenges, educators recognized AI as a powerful tool for enhancing personalized learning and improving efficiency in teaching. AI-driven platforms allow students to receive adaptive feedback, targeted tutorials, and self-paced learning materials, addressing individual learning needs. Additionally, AI-assisted grading and lesson planning have reduced teachers' workload, enabling them to focus more on practical instruction.

"AI has allowed me to provide customized learning experiences for students. Those who struggle with certain skills can receive extra AI-guided tutorials, which enhance their learning."

"AI has improved my efficiency in lesson planning and assessment. I use AI-powered grading tools to check students' work, giving me more time to focus on practical instruction."

Acknowledging AI's benefits indicates that educators see AI as a tool for improving student engagement and instructional efficiency. However, these advantages can only be fully realized if AI tools are integrated strategically and supported by adequate training and institutional resources. The findings suggest that AI can redefine skill-based learning if access and usability challenges are addressed.

Pedagogical Shifts and Instructional Strategies in Response to AI-Driven Educational Innovations

Integrating Artificial Intelligence (AI) in Technology and Livelihood Education (TLE) reshapes blended learning and assessment practices, creating a more adaptive and student-centered environment. Educators reported adopting blended learning strategies that combine AI-driven instruction with hands-on practice, enabling students to engage with technical skills in structured and progressive ways. Virtual simulations and online modules provide a safe space for preliminary training, while face-to-face workshops allow practical application, bridging the gap between theory and practice. This approach enhances flexibility and accommodates diverse learning needs by offering self-paced lessons that students can revisit anytime. At the same time, AI has influenced how teachers assess and monitor student performance, moving beyond traditional examinations toward dynamic, continuous, and formative assessments. AI-powered quizzes, instant feedback systems, and skill-tracking tools have allowed educators to provide immediate guidance and targeted support, ensuring that learning gaps are addressed in real time. These innovations highlight a significant pedagogical shift in vocational education, where teaching and assessment are becoming more interactive, personalized, and competency-based. The findings suggest that when integrated effectively, AI can strengthen learning and evaluation processes, improving student confidence, mastery of skills, and readiness for real-world applications.

Integration of AI for Blended Learning Approaches

Educators reported adopting blended learning strategies that combine AI-driven digital instruction with hands-on practical exercises. Virtual simulations and online modules have provided preliminary exposure to skills before actual application, making learning more structured and progressive. AI-powered resources have also allowed educators to deliver flexible and self-paced lessons, accommodating diverse learning needs.

"I have started using AI-powered virtual simulations alongside hands-on workshops. Students can first practice digitally before performing real-life applications in the workshop."

"My teaching has become more flexible. AI tools help me offer online modules that students can revisit anytime, complementing our in-class practical lessons."

Integrating AI into blended learning models signifies a significant pedagogical shift in vocational education. This approach bridges the gap between theoretical understanding and hands-on practice, making TLE instruction more adaptive and

inclusive. The findings suggest that blended learning, supported by AI, can improve students' confidence and mastery of skills before engaging in real-world applications.

Adjustments in Assessment and Feedback Mechanisms

AI has influenced how educators assess student progress, shifting from traditional testing to more dynamic, AI-assisted evaluation tools. Teachers have incorporated AI-generated quizzes, real-time feedback mechanisms, and skill-tracking tools to monitor student learning. These tools allow educators to provide immediate guidance and more personalized feedback.

"I now incorporate AI-generated quizzes and instant feedback tools in my classes. It helps students assess their learning in real time and make improvements."

"Instead of relying only on traditional tests, I now use AI-powered skill-tracking tools to monitor students' progress. This way, I can provide more targeted guidance for their skill development."

This shift reflects a growing emphasis on continuous and formative assessment rather than relying solely on summative evaluations. AI-powered assessment methods enhance the accuracy and efficiency of skill evaluation, making it easier for educators to track student performance in real time. The findings suggest that AI can serve as a valuable support system in competency-based learning, where real-time feedback is essential for student improvement.

Discussion

Integrating Artificial Intelligence (AI) in Technology and Livelihood Education (TLE) has generated diverse perceptions among educators, reflecting optimism about its potential and caution about its limitations. Many TLE teachers expressed a positive outlook toward AI, emphasizing its role in enhancing lesson engagement and supporting personalized learning. They noted that AI-powered simulations allow students to visualize technical skills such as cooking procedures, electrical wiring, or sewing techniques before practicing them in real-life workshops. This digital exposure prepares students to enter hands-on sessions more confidently and accurately, bridging the gap between theoretical understanding and practical application. Similar findings were reported by Jia, Zhou, and Zhang (2022), who demonstrated that AI-powered simulations in vocational contexts improve engagement and help students translate theoretical knowledge into practical skills. Teachers also acknowledged that AI-driven platforms enable students to learn at their own pace, catering to varying skill levels in the classroom. Struggling learners can be guided step by step, while advanced learners are challenged with more complex tasks, ensuring inclusiveness

and addressing individual needs. This sense of optimism suggests that AI has significant potential in vocational education, aligning with TLE's competency-based orientation where mastery of skills is the primary goal (Garcia & Rivera, 2022; Wang, Chen, & Patel, 2021).

Despite this enthusiasm, skepticism persists among educators. Some voiced concerns that AI cannot replicate the tactile and experiential learning fundamental to vocational training. For instance, no simulation can fully replace the feel of handling culinary ingredients, repairing an actual appliance, or engaging in real-world entrepreneurship. Zhu, Green, and Moore (2020) emphasized that while AI and digital tools can enhance technical learning, they should never replace authentic hands-on practice, central to vocational competence. Teachers feared that an over-reliance on AI could reduce hands-on practice, weaken authentic learning, and potentially diminish the essential human mentoring that forms the backbone of vocational education.

Furthermore, many educators admitted uncertainty and hesitation, citing their lack of training in AI integration and unfamiliarity with the tools. This reflects findings by Sun, Wang, and Liu (2022), who argued that many teachers lack both the confidence and skills to incorporate AI effectively in their classrooms. Meyer and Schubert (2020) noted that professional development is critical to ensure teachers can balance technological innovation with sound pedagogy. These insights highlight the importance of providing professional development opportunities so teachers can gain the technical skills and pedagogical confidence necessary to maximize AI's benefits without undermining traditional instructional approaches.

Another recurring theme in educators' experiences was the presence of structural challenges and opportunities in the adoption of AI. On one hand, schools in urban or better-resourced areas could integrate AI tools more effectively because of stronger internet connectivity, available devices, and administrative support. On the other hand, educators in rural or underfunded schools pointed to limited infrastructure, unreliable technology, and inadequate training as significant barriers. Li and Zhao (2021) confirmed that technological disparities in developing countries, particularly in vocational education, continue to exacerbate educational inequities. Teachers expressed frustration that they were expected to use AI without sufficient workshops or technical assistance, leaving them underprepared to navigate AI platforms in their classrooms. These constraints mirror broader issues of digital inequity highlighted by Sang, Rivas, and Thompson (2021), who documented teachers' fears of AI replacing traditional methods while they remained undertrained and unsupported.

Nevertheless, educators also acknowledged the opportunities AI presents. For example, automated grading systems reduced their workload, while AI-generated quizzes and adaptive tutorials provided instant feedback that helped students track their progress. Chen, Martinez, and Klein (2023) found similar efficiencies in blended AI learning environments, where automation allowed educators to focus on higher-order tasks rather than repetitive assessments.

AI integration has also reshaped pedagogy and instructional strategies in TLE. Many educators described adopting blended learning models that combined AI-powered modules with traditional hands-on practice. Virtual simulations and online resources offered students a safe, structured environment for preliminary training, while classroom workshops reinforced practical skills through physical application. This blended approach was particularly valuable in preparing students for real-world applications, allowing them to practice, reflect, and refine their techniques. Brown and Taylor (2022) noted that AI-powered assessments provide opportunities for personalized, continuous feedback while supporting blended instructional models. Moreover, educators highlighted how AI influenced assessment practices. Rather than relying solely on static, summative tests, they used AI-assisted evaluation tools such as real-time feedback mechanisms, skill-tracking systems, and dynamic quizzes. These tools enabled continuous and formative assessment, making it easier for teachers to identify learning gaps and provide targeted interventions. According to Wang et al. (2021), such adaptive learning platforms are particularly effective in vocational contexts because they support competency-based evaluation. It represents a significant pedagogical shift toward more interactive, student-centered, and competency-based instruction, where technology enhances, not replaces, the development of practical skills and critical thinking.

In summary, the perceptions and experiences of TLE educators in integrating AI into vocational instruction reveal a nuanced landscape shaped by both opportunities and challenges. Optimism arises from AI's ability to make lessons more engaging, personalize instruction, and improve efficiency. At the same time, skepticism stems from its inability to replicate hands-on practice fully, concerns about teacher readiness, and persistent inequities in access. These dual perspectives underscore the importance of designing culturally responsive and pedagogically balanced frameworks for AI integration that safeguard TLE's tactile, community-based, and experiential essence while harnessing the benefits of digital innovation. By aligning AI adoption with adequate teacher training, institutional support, and context-specific strategies, educators can ensure that AI enhances rather than

diminishes the vocational learning experience, ultimately preparing students with the skills, confidence, and cultural grounding needed for real-world success.

Conclusion

This study examined TLE educators' perceptions, challenges, and pedagogical adaptations in integrating AI into vocational instruction. Key findings indicate that educators view AI as a valuable tool for enhancing personalized learning and student engagement. However, concerns about over-reliance on AI highlight the need to balance digital tools with hands-on training. AI adoption in TLE presents both challenges and opportunities. Limited access to AI tools, insufficient training, and infrastructure gaps hinder integration, especially in under-resourced schools. Despite this, AI has the potential to streamline instruction and support tailored learning, emphasizing the need for equitable access and professional development.

AI integration has also led to pedagogical shifts, including blended learning approaches and AI-assisted assessments. Teachers are incorporating virtual simulations, self-paced modules, and real-time feedback, signaling a move toward more flexible and data-driven instruction. AI has transformative potential in TLE, but strategic implementation is crucial. Future efforts should focus on bridging the digital divide, enhancing teacher training, and ensuring AI support rather than replacing hands-on skill development.

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