

**Integrating technology in TLE for SDG alignment: A framework
for enhancing Tech-Voc skills and promoting sustainable development**

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ABSTRACT

The integration of technology in Technology and Livelihood Education (TLE) has become essential for enhancing students' technical-vocational skills, fostering creativity and innovation, and promoting sustainable learning aligned with the United Nations Sustainable Development Goals (SDGs). This study aimed to determine the level of technology integration in TLE instruction, assess its effectiveness in developing 21st-century competencies, and examine the influence of teachers' demographic profiles on their perceptions of technology-enhanced instruction toward SDG alignment. A descriptive-correlational research design was employed involving 40 TLE teachers, 100 students from various grade levels, and 2 Administrators. Data were collected using structured questionnaires covering teacher demographics, technology integration practices, resource availability, teacher competency, and perceptions of instructional effectiveness. Descriptive statistics such as frequency, percentage, mean, and standard deviation were used to analyze the level of integration and effectiveness, while ANOVA was applied to examine the relationship between teacher profiles and perceived effectiveness. The results revealed a high level of technology integration in TLE, particularly in enhancing critical thinking, collaboration, creativity, and practical skills, with an overall mean of 3.87. Technology-integrated instruction was also highly effective in promoting students' technical-vocational competencies and environmental awareness (overall mean = 4.06). Significant differences in perceptions were observed based on teachers' age and teaching experience, indicating that maturity and professional exposure influence technology adoption. The study highlights the importance of adequate hardware, software, internet connectivity, and technical support systems, as well as continuous professional development and administrative support, for successful technology integration. These findings provide actionable insights for curriculum designers, educators, and policymakers to strengthen technology-enhanced TLE instruction and ensure alignment with SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure).

Keywords: Vocational Education, Technology Integration, TLE Instruction, SDG Alignment, 21st-Century Competencies, Technical-Vocational Skills, Teacher Competency, CTU-Main Campus, Cebu Philippines.

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INTRODUCTION

In today's rapidly evolving world, integrating technology into education has become a crucial pathway to achieving sustainability and inclusivity (Selwyn, 2016; UNESCO, 2023). The infusion of technology in Technical and Livelihood Education (TLE) enhances learners' practical competencies while fostering innovation and environmental awareness (Arcadio, 2025). Technological integration enables students to connect traditional technical skills with modern digital tools, preparing them for the demands of Industry 4.0 (Alviola, 2025). Similarly, technology-driven TLE instruction promotes creativity, productivity, and adaptability among learners (Capote, 2025). This study emerges from the need to align TLE practices with Sustainable Development Goals (SDGs) through the meaningful application of technology in technical-vocational education (Fullan, 2015; OECD, 2019).

This study focuses on developing a framework that integrates technology into TLE for SDG alignment, aiming to enhance technical-vocational skills while promoting sustainable development (UNESCO, 2023; World Bank, 2020). Such integration serves as a bridge between skill-based learning and global sustainability initiatives (Medio, 2025). Aligning TLE with SDGs ensures that students not only acquire employable skills but also become agents of environmental stewardship and social responsibility (Archival, 2025). Technology-integrated TLE further fosters green innovation and supports inclusive growth within communities (Lumbab, 2025). Therefore, this research seeks to propose an educational framework that connects technological advancement with sustainability-oriented competencies (Schleicher, 2018; UNESCO, 2023).

Education systems must reorient TLE curricula toward sustainability and digital literacy to meet global development targets (UNESCO, 2023). The integration of emerging technologies into vocational education enhances efficiency, creativity, and long-term employability (Wang & Xu, 2022). In the Philippine context, the Department of Education (2024) emphasized that TLE should incorporate technology-based practices to achieve SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure). These perspectives collectively affirm that education must evolve to address both technological and sustainability challenges through policy, pedagogy, and practice (Darling-Hammond, 2017; Fullan, 2015).

However, several gaps remain in the full integration of technology in TLE toward SDG realization (UNESCO, 2023; OECD, 2019). Many TLE programs still rely heavily on traditional methods, lacking digital and sustainability components (Pajaron, 2025). Inconsistencies in resource availability, teacher readiness, and institutional support for technology-driven TLE instruction have likewise been documented (Arcadio, 2025). Moreover, existing frameworks seldom consider how TLE can actively contribute to achieving multiple SDGs beyond employment generation (Medio, 2025). These gaps highlight the urgency of establishing a systematic framework for sustainable, technology-enhanced TLE instruction (Schleicher, 2018; World Bank, 2020).

This study is grounded in several theoretical frameworks that collectively support the integration of technology in TLE toward sustainable development. The Technological Pedagogical Content Knowledge (TPACK) Theory (Mishra & Koehler, 2006) underscores the interconnection among technology, pedagogy, and content knowledge, positing that effective teaching in the digital age requires educators to integrate these elements harmoniously to facilitate meaningful learning experiences (Koehler et al., 2014). In the context of TLE, TPACK guides teachers to strategically incorporate modern technological tools while maintaining the integrity of technical content (UNESCO, 2023; OECD, 2019), promoting the understanding that technology should function not as an add-on but as an enabler that transforms instruction and enhances the teaching-learning process (Harris, 2016; Mishra, 2019). Applying TPACK to TLE challenges teachers to adapt pedagogical strategies to meet

the demands of Industry 4.0 while addressing the SDGs (World Economic Forum, 2020; UNESCO, 2023), encouraging the use of digital simulations, virtual workshops, and online collaborative tools to enhance learners' technical and problem-solving skills (Selwyn, 2016; OECD, 2019). By aligning pedagogy with technology and content, TLE teachers can cultivate sustainability awareness and innovation among students (UNESCO, 2023; World Bank, 2020), thereby developing 21st-century learners who are technologically adept, environmentally conscious, and capable of adapting to evolving global industries (Schleicher, 2018; OECD, 2019).

Constructivist Learning Theory (Vygotsky, 1978) emphasizes that learning is an active, social, and contextual process in which students construct knowledge through interaction and experience (Bruner, 1966; OECD, 2019). In a technology-integrated TLE environment, this theory supports the notion that learners build understanding through collaborative and practical engagement with both digital tools and physical materials (Selwyn, 2016; UNESCO, 2023), with teachers serving as facilitators who guide students to discover concepts and solutions through experimentation and reflection (Bruner, 1966; Vygotsky, 1978). The integration of technology through digital design software, simulation tools, and virtual laboratories enhances learners' engagement and enables them to connect theory with real-world applications. Constructivism in TLE fosters critical thinking, creativity, and innovation essential to promoting sustainability and lifelong learning, and through authentic tasks such as project-based and problem-based learning, TLE instruction encourages learners to explore eco-friendly practices and sustainable production methods. The collaborative nature of constructivism aligns with SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure), reinforcing the importance of inclusive and transformative education, and empowering students to become proactive contributors to sustainable communities.

Kolb's Experiential Learning Theory (1984) highlights that learning occurs through a continuous cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation. In TLE, this theory is particularly relevant as it prioritizes hands-on learning experiences that bridge theory and practice, engaging learners in activities such as tool handling, machinery operation, food processing, and electrical wiring, followed by reflection that generates insights for improved future performance. When integrated with technology, experiential learning allows students to simulate industrial environments, conduct digital assessments, and explore sustainable innovations through virtual and augmented reality. Experiential learning further supports sustainable education by encouraging reflection on real-world issues such as resource management, environmental impact, and ethical production, leading TLE learners toward more responsible and sustainable approaches in their technical work. This theory aligns with the goal of producing graduates who are skilled in technical fields and simultaneously aware of their roles in fostering sustainable development, making the TLE curriculum a dynamic platform for cultivating both competence and conscience.

The Sustainable Development Theory introduced by the Brundtland Commission (1987) defines sustainable development as meeting the needs of the present without compromising the ability of future generations to meet their own. This theory provides a foundation for integrating sustainability principles into TLE, where technical skills directly influence economic and environmental outcomes, calling on education systems to develop learners' competencies in resource conservation, waste reduction, and green innovation. By incorporating technology into TLE, schools can promote practices such as digital design for efficiency, renewable energy utilization, and sustainable production systems that contribute to long-term societal well-being. This theory aligns TLE objectives with global priorities outlined in the United Nations' SDGs, emphasizing the role of technical-vocational education in

advancing SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible Consumption and Production). Educators are thereby encouraged to integrate sustainability across curriculum content, ensuring that learners understand the environmental and social implications of their work, so that TLE functions not only as a means of economic empowerment but also as a vehicle for promoting ecological responsibility and global citizenship.

This study is further anchored in pertinent legislative frameworks that underscore the policy mandate for technology-enhanced and sustainability-driven TLE in the Philippines. Republic Act No. 10533, or the Enhanced Basic Education Act of 2013, strengthens the K-12 curriculum by emphasizing the use of technology and innovation to develop learners' 21st-century skills. The law mandates the integration of ICT and technical-vocational content in basic education to prepare students for higher education, employment, and entrepreneurship, while promoting contextualized learning that connects classroom instruction to real-life applications including sustainable and community-based projects. In TLE, this law supports the use of technology to enhance instruction and align with SDG 4 by ensuring equitable, relevant, and transformative learning experiences. RA 10533 also encourages schools to adopt flexible and innovative teaching methods that embed sustainability principles into the curriculum, providing a strong policy foundation for preparing learners to meet both local and global workforce demands responsibly. Complementing this legislation, Republic Act No. 10687, known as the UniFAST Act of 2015, ensures that qualified Filipino students have access to financial support for tertiary and technical-vocational education by consolidating all government-funded scholarship, grant, and loan programs to promote inclusivity and equal opportunity. This act empowers learners pursuing TLE and tech-voc courses to complete their education without financial barriers, directly contributing to SDG 8 (Decent Work and Economic Growth) by equipping students with employable skills needed in the technology-driven economy. RA 10687 further underscores the government's commitment to enhancing access to quality education and fostering human capital development through technical training, supporting technology integration in TLE instruction and reinforcing education's role as a catalyst for sustainable socioeconomic progress.

This study is significant because it aims to contribute to both educational innovation and sustainable development (Darling-Hammond, 2017; UNESCO, 2023). By aligning TLE with the SDGs, schools can produce graduates equipped with technical expertise and global citizenship values (Alviola, 2025). This integration not only improves teaching and learning but also empowers communities to engage in eco-friendly and socially responsible practices (Capote, 2025). The proposed framework may further serve as a model for policy formulation, curriculum enhancement, and teacher training (Lumbab, 2025). Overall, this research aspires to transform TLE into a powerful instrument for achieving inclusive, equitable, and sustainable development in the digital era (Fullan, 2015; Selwyn, 2016).

Statement of the problem

This research evaluates how technology is integrated into Technical and Livelihood Education (TLE) in alignment with Sustainable Development Goals (SDGs), with the aim of developing a framework that strengthens technical-vocational (Tech-Voc) competencies while advancing sustainable development. Specifically, it sought answers to the following questions:

1. What is the demographic profile of the respondents in terms of the teachers' age and gender, highest educational attainment, teaching experience, specialization, and participation in professional development or training related to technology and TLE, as well as the students' grade level and sections?

2. What is the current status of technology integration in TLE instruction as implemented in schools in terms of curriculum design, instructional delivery, resource availability, teacher competency, and administrative support?
3. What are the identified technical requirements necessary for the effective integration of technology in TLE instruction in terms of SDG alignment, hardware, software, internet connectivity, and technical support systems?
4. As perceived by the respondents, what is the level of integration of technology in TLE in promoting sustainable learning outcomes and developing 21st-century competencies aligned with SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure)?
5. As rated by the respondents, what is the level of effectiveness of the technology-integrated TLE instruction in enhancing students' technical-vocational skills, creativity, innovation, and environmental awareness?
6. Is there a significant relationship between the respondents' profile and their perception of the effectiveness of technology integration in TLE instruction toward SDG alignment?
7. Based on the findings, what Strategic Plan may be proposed to strengthen technology integration in TLE for enhancing Tech-Voc skills and promoting sustainable development?

METHODOLOGY

This chapter presents the methods and procedures employed in conducting the study, encompassing the research design, the environment in which the study was conducted, the respondents, the data-gathering instruments, the data collection procedures, and the statistical treatment of data. The methodology serves as a systematic framework that ensures the accuracy, reliability, and validity of the results in alignment with the objectives of the research. Through the components detailed in this chapter, the researcher provides a clear account of how the study was carried out, including the rationale for selecting specific research approaches and instruments that best capture respondents' perceptions, the system's technical requirements, and the overall level of effectiveness and acceptability. This section ultimately grounds the study's findings in scientific rigor and positions them as a reliable basis for the proposed technological intervention.

The study employed a descriptive-developmental research design, which combines descriptive and developmental approaches to systematically assess, analyze, and develop a technological solution based on identified needs. The descriptive component focused on gathering data about the respondents' profiles, perceptions, and assessments of existing instructional practices, while the developmental component aimed to design and propose a digitalized management system aligned with the study's findings. This design was selected because it allows for both the evaluation of current conditions and the creation of an innovative output to address existing challenges. The descriptive approach yielded quantitative data that characterized the current status and technical requirements of the system from the perspectives of students, instructors, and administrators, while the developmental aspect was utilized to conceptualize, design, and propose a sustainable technological model intended to enhance efficiency, functionality, and user satisfaction. By integrating these two approaches, the study ensured a comprehensive understanding of the problem, guided the development of a feasible solution, and supported evidence-based decision-making for technological implementation.

Flow of the study

The study is structured to systematically explore the integration of technology in Technology and Livelihood Education (TLE) for enhancing technical-vocational skills and promoting sustainable development. The flow of the study is organized around three interconnected phases: input, process, and output. The input phase encompasses the demographic profile of the respondents; the current status of technology integration in TLE instruction as implemented in schools; the identified technical requirements necessary for the effective integration of technology in TLE instruction; the level of technology integration in TLE in promoting sustainable learning outcomes and developing 21st-century competencies aligned with Sustainable Development Goal 4 (SDG 4); the level of effectiveness of technology-integrated TLE instruction in enhancing students' technical-vocational skills; and the nature of the significant relationship between the respondents' profile and their perception of the effectiveness of technology integration in TLE instruction toward SDG alignment.

The process phase involves a series of systematic and organized research activities beginning with the preparation and submission of a Letter of Intent to secure permission to conduct the study. Once approved, the researcher proceeded to conduct the research survey, followed by the distribution of questionnaires to the identified respondents. After the allotted response period, the accomplished questionnaires were collected and tabulated to organize the data for presentation and interpretation. The data then underwent statistical analysis to determine trends, relationships, and significant findings relevant to the study's objectives. Lastly, the researcher interpreted the analyzed data to derive conclusions and recommendations that guide the development of an enhanced framework for technology integration in TLE instruction.

The output phase focuses on the formulation of a proposed strategic framework designed to strengthen technology integration in TLE for enhancing technical-vocational skills and promoting sustainable development. This framework serves as a strategic guide for educators, administrators, and policymakers in aligning TLE instruction with the Sustainable Development Goals, particularly SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure). It integrates the findings from the respondents' profiles, the current status of technology use, technical requirements, and perceived effectiveness into a coherent model that supports innovation, sustainability, and skill advancement. The proposed framework aims to enhance teaching and learning practices through the effective use of digital tools, experiential learning, and sustainability-oriented pedagogy, ultimately empowering learners with 21st-century competencies relevant to both education and industry.

Environment

The study was conducted at Cebu Technological University (CTU) Pinamungajan Campus, located in the municipality of Pinamungajan, Cebu. CTU Pinamungajan Campus is one of the extension campuses of Cebu Technological University, a premier state university in the region committed to providing quality education in science, technology, and innovation. The campus offers a range of programs, including Technology and Livelihood Education, Technical-Vocational, and Industrial Technology courses that aim to develop students' practical skills and technological competencies. With its strong emphasis on applied learning, the campus serves as an ideal environment for investigating the integration of technology in TLE instruction, particularly in the context of aligning educational practices with sustainable development goals.

The physical and learning environment at CTU Pinamungajan Campus provides access to various instructional facilities such as computer laboratories, workshops, and skill-based

learning areas that support hands-on training and digital innovation. These facilities are designed to complement TLE instruction and enhance students' learning experiences through technology-driven methodologies. The campus also fosters a culture of collaboration among students and faculty members, encouraging continuous improvement and adaptation to emerging educational technologies. This environment creates a realistic setting for assessing how technology integration contributes to the enhancement of technical-vocational skills and sustainability-focused competencies among learners. CTU Pinamungajan Campus operates within a community-oriented framework, maintaining close ties with local industries, government agencies, and community partners, which strengthens the campus's role in promoting employability, entrepreneurship, and sustainable practices among students. The surrounding community of Pinamungajan, characterized by a growing economy supported by agriculture, tourism, and small enterprises, provides a practical backdrop for TLE-related activities and projects. This dynamic interaction between the university and its local environment supports the implementation and evaluation of technology-integrated instruction that responds to both educational and community needs. Overall, the campus's commitment to technological advancement, sustainable education, and community engagement aligns with the objectives of this research, making CTU Pinamungajan an appropriate and conducive venue for the study.

Respondents

The respondents of the study consist of three primary groups from Cebu Technological University Pinamungajan Campus: students, instructors, and administrators who are directly involved in the implementation and experience of TLE. These respondents were chosen purposively based on their participation in teaching, learning, and management of TLE instruction. The inclusion of these groups provides a comprehensive understanding of how technology integration is practiced and perceived within the academic environment, with their responses forming the basis for assessing the current status, effectiveness, and sustainability alignment of technology-integrated TLE instruction in enhancing technical-vocational skills. The total population of respondents was 142 (N=142). Of this total, 100 respondents were students, representing 70.42% of the sample, while 42 respondents were instructors and administrators, representing 29.58%. The data indicate that the majority of respondents are students, meaning the study is largely shaped by student perspectives as the primary beneficiaries of TLE. This strong student representation provides valuable insights into how technology integration influences learning experiences and skill development. However, the smaller proportion of instructors and administrators suggests that institutional and instructional viewpoints are less emphasized, which may limit a more comprehensive understanding of implementation, policy, and systemic factors. Overall, the distribution reflects a learner-centered focus, and the findings should be interpreted with consideration of the relatively lower representation of educators and decision-makers.

Research instrument

The study employs a structured questionnaire as the primary instrument to gather data on the integration of technology in TLE for enhancing technical-vocational skills and promoting sustainable development. Questionnaires are widely recognized as effective tools for collecting standardized data from a large group of respondents, allowing for both quantitative and qualitative analysis (Creswell & Creswell, 2018). The instrument is designed

to assess three key dimensions. The first dimension, technology integration in TLE, measures the extent to which digital tools, simulations, and innovative technologies are incorporated into TLE instruction, aligning with the framework proposed by Mishra and Koehler (2006) on Technological Pedagogical Content Knowledge (TPACK), which emphasizes the integration of technology with pedagogy and content knowledge. The second dimension, SDG alignment in TLE projects, evaluates how TLE activities and projects contribute to the United Nations Sustainable Development Goals, particularly those related to quality education, sustainable consumption, and decent work (United Nations, 2015). The third dimension, effectiveness in enhancing technical-vocational skills, assesses the impact of technology-enhanced TLE on students' practical competencies, problem-solving abilities, and readiness for employment, drawing on the principles of competency-based education as outlined by Blanchard et al. (2019), which emphasizes measurable skill acquisition and mastery learning. The questionnaire combines Likert-scale items for quantitative measurement and open-ended questions to capture qualitative insights, ensuring comprehensive data collection that enables the study to identify patterns, challenges, and best practices in integrating technology for sustainable and skill-focused TLE instruction.

Data gathering procedure

Prior to data collection, a Letter of Intent was submitted to the Campus Director of CTU Pinamungajan Campus to secure approval to conduct the study. Upon approval, the researcher sought the assistance of the TLE coordinator and faculty members to identify eligible respondents. The questionnaires were carefully reviewed, pre-tested, and finalized to ensure clarity, consistency, and relevance to the research objectives. All ethical considerations, including informed consent and confidentiality, were strictly observed throughout the process. The researcher personally distributed the questionnaires to the identified respondents, namely students, instructors, and administrators. A short orientation was provided to explain the purpose of the study and ensure that respondents clearly understood each item. Respondents were given sufficient time to complete the questionnaires, after which the accomplished forms were retrieved. For convenience, some respondents were also allowed to answer electronically through a Google Form version of the same instrument to ensure wider participation and accessibility.

Statistical treatment and scoring

The collected data were encoded, tabulated, and analyzed using descriptive and inferential statistics. Descriptive statistics including frequency, percentage, weighted mean, and standard deviation were used to describe respondents' demographic profiles and assess their perceptions of technology integration in TLE instruction. Inferential statistics, specifically the Pearson r correlation, were applied to determine the significant relationship between respondents' profiles and their perceptions of technology integration toward SDG alignment.

The weighted mean was used to determine the overall perception and effectiveness rating of technology integration in TLE instruction. It was computed using the formula $\bar{X} = \sum fX / N$, where $\bar{X}$ denotes the weighted mean, f represents the frequency of responses, X represents the weight assigned to each response, and N represents the total number of responses. The resulting means were interpreted using a five-point scale with corresponding verbal interpretations: Very Highly Effective (5), Highly Effective (4), Effective (3), Moderately Effective (2), and Less Effective (1). The standard deviation (SD) was used to determine the degree of variability or consistency of respondents' responses from the computed mean. A low standard deviation indicates that responses are close to the mean, reflecting high

consistency, while a high standard deviation indicates greater variability among responses. It was computed using the formula $SD = \sqrt{[\sum(X - \bar{X})^2 / (N - 1)]}$. This statistical tool provided deeper insights into how consistently respondents perceived the integration of technology in TLE instruction across different groups.

Each response in the questionnaire was assigned a numerical weight based on the Likert scale, where 5 corresponds to Strongly Agree or Very Highly Effective, 4 to Agree or Highly Effective, 3 to Moderately Agree or Effective, 2 to Disagree or Moderately Effective, and 1 to Strongly Disagree or Less Effective. The weighted mean for each indicator was computed and interpreted based on predetermined score ranges to determine the overall level of technology integration, effectiveness, and sustainability alignment in TLE instruction.

The assessment scale for acceptability was applied to interpret the weighted mean results obtained from respondents' evaluations. A weighted mean ranging from 4.21 to 5.00 corresponds to a verbal description of Very Highly Acceptable, indicating that the technology integration in TLE is excellent, comprehensive, and fully aligned with SDG objectives. A range of 3.50 to 4.20 corresponds to Highly Acceptable, indicating that the integration is effective and well-implemented, with minor areas for enhancement. A range of 2.70 to 3.40 corresponds to Moderately Acceptable, indicating that the integration is functional but needs improvement in consistency and sustainability aspects. A range of 1.90 to 2.60 corresponds to Acceptable, indicating that the integration meets minimum standards but lacks full alignment with desired outcomes. A range of 1.00 to 1.80 corresponds to Not Acceptable, indicating that the integration is inadequate or ineffective, showing minimal or no contribution to TLE improvement. This assessment scale guided the analysis of how well current practices meet educational and developmental standards and served as the foundation for the proposed framework.

RESULTS AND DISCUSSION

This chapter presents and interprets the findings derived from data gathered from a total of 142 respondents, comprising 42 teacher and administrator respondents and 100 student respondents, who participated in this descriptive-correlational study on the integration of technology in Technology and Livelihood Education (TLE) instruction. Respondents were selected through purposive sampling, and data were collected using structured survey questionnaires designed to measure perceptions of technology integration, its technical requirements, its level of implementation, and its effectiveness in promoting sustainable learning outcomes aligned with Sustainable Development Goal 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure). Descriptive statistics including frequencies, percentages, means, and standard deviations were used to characterize and interpret the data, while inferential analysis through one-way analysis of variance (ANOVA) was employed to examine significant relationships between respondents' profiles and their perceptions of the effectiveness of technology integration in TLE instruction. All results and interpretations presented in this chapter are grounded in the data gathered and are discussed in direct relation to the objectives of the study.

Demographic profile of the respondents

Age and gender of teacher and administrator respondents

An examination of the age and gender distribution of the 42 teacher and administrator respondents reveals that the largest proportion belongs to the 30 to 39 age group, which accounts for 33.33% of the sample (14 respondents), followed by those aged 40 to 49 at 26.19% (11 respondents). Respondents in both the 20 to 29 and 50 to 59 age brackets are equally represented, each comprising 19.05% (8 respondents), while the smallest group consists of a single respondent aged 60 and above, representing only 2.38% of the total. With respect to gender, 18 respondents are male and 22 are female. The overall distribution suggests that the majority of the teacher and administrator respondents are in their early to mid-career stages, indicating a workforce that is relatively young, professionally active, and likely receptive to instructional innovations such as technology integration in TLE. The balanced representation across multiple age brackets further reflects a productive mix of emerging and experienced educators whose diverse perspectives may enrich the understanding of TLE program implementation. The notably minimal representation of the 60 and above group, however, may result in limited experiential insights from professionals nearing retirement, which could marginally affect the depth of longitudinal perspectives within the study.

Educational attainment of teacher and administrator respondents

The educational profile of the teacher and administrator respondents reflects a highly qualified teaching force. The largest proportion holds a master's degree (45.00%), followed by those with master's units (25.00%), those holding only a bachelor's degree (15.00%), those with doctoral units (10.00%), and those who have completed a doctorate degree (5.00%). The combined proportion of respondents who have attained or are pursuing a graduate degree reaches 85%, which implies a strong academic foundation capable of supporting the nuanced demands of technology-enhanced TLE instruction. Educators with higher educational attainment are generally better positioned to adapt curricula in alignment with SDGs and 21st-century competencies, and may additionally serve as internal mentors to colleagues in the adoption of digital instructional strategies.

Teaching experience of teacher and administrator respondents

The distribution of teaching experience among the respondents reveals a workforce composed primarily of moderately experienced professionals. The largest group has between 6 and 10 years of experience (11 respondents), followed by those with 11 to 15 years (10 respondents), 16 to 20 years (8 respondents), 1 to 5 years (7 respondents), and 21 years and above (6 respondents). This range of experience levels indicates a balanced coexistence of early-career adaptability and seasoned pedagogical expertise within the respondent pool. Professionals in the middle experience brackets bring sufficient familiarity with classroom practice to meaningfully evaluate instructional strategies while remaining professionally open to growth and innovation. The inclusion of both newer and longer-serving educators strengthens the validity of the study's insights by capturing both responsiveness to modern instructional technologies and grounded vocational knowledge accumulated over years of practice.

Area of specialization of teacher and administrator respondents

The specialization profile of the respondents is predominantly concentrated in technical and vocational disciplines, reinforcing the relevance of their perspectives in evaluating technology integration in TLE. The largest group specializes in Technology and Livelihood Education (14 respondents, 35.00%), followed by Industrial Technology (11 respondents,

27.50%), Information Technology (7 respondents, 17.50%), Engineering-related fields (5 respondents, 12.50%), General Education (3 respondents, 7.50%), and other specializations (2 respondents, 5.00%). The strong representation from TLE and Industrial Technology indicates direct exposure to competency-based and skills-based instruction, which lends authority to respondents' assessments of technology-integrated TLE programs. The presence of Information Technology and Engineering-related specialists further contributes technical and digital innovation perspectives that are directly pertinent to the study's focus. The relatively modest representation from General Education and other fields, while slightly narrowing the diversity of academic viewpoints, does not diminish the technical coherence of the respondent group and is appropriate given the specialized nature of the study.

Participation in professional development or training

A substantial majority of the teacher and administrator respondents, 32 individuals, representing 80.00%, have participated in professional development or training programs related to technology and TLE, while the remaining 8 respondents (20.00%) have not. This high participation rate reflects strong institutional engagement in capacity-building initiatives and suggests that most educators in the sample are actively acquiring the competencies needed to implement technology-integrated instruction effectively. The breadth of this professional engagement is indicative of readiness to utilize digital tools and adopt instructional strategies aligned with the SDGs, and positions this teaching workforce favorably for sustaining and advancing technology integration in TLE programs.

Grade level and section distribution of student respondents

The 100 student respondents are distributed across four sections spanning two grade levels. First Year BTLED 1-A accounts for 25 respondents (25.00%), First Year BTLED 1-1 for 26 respondents (26.00%), Third Year BTLED 3-A for 24 respondents (24.00%), and Third Year BTLED 3-1 for 25 respondents (25.00%). The near-equal distribution across first-year and third-year sections provides a balanced sample that supports meaningful cross-level comparisons, enabling the study to examine how technology integration differentially affects learning outcomes and the development of 21st-century competencies at distinct stages of a student's academic progression in TLE.

Current status of technology integration in TLE instruction

Curriculum design

The analysis of curriculum design reveals that technology integration in the TLE curriculum is evident at moderate to high levels, reflecting the inclusion of digital tools, competency-based outcomes, and technology-enhanced learning activities. The curriculum is generally aligned with national educational standards and industry-relevant competencies, thereby enabling learners to develop practical and technological skills applicable to real-world settings. Nonetheless, the integration of emerging technologies and the currency of curriculum content remain ongoing challenges, suggesting that despite foundational alignment, curriculum responsiveness to rapid technological advancements and evolving industry demands requires sustained attention. These findings imply that while TLE learners are gaining pertinent digital and practical skills through the existing curriculum, gaps in the adoption of cutting-edge

technologies may limit graduates' readiness for fast-moving workplaces. Regular curriculum review, stronger industry linkages, and continuous teacher upskilling are therefore necessary to ensure timely integration of new tools and practices. Institutional mechanisms that support curriculum innovation, together with flexible policy frameworks, are essential to maintaining relevance, enhancing graduate employability, and keeping TLE instruction responsive to both technological progress and industry expectations.

Instructional delivery

With respect to instructional delivery, TLE teachers employ a range of technology-supported strategies, including multimedia presentations, demonstration videos, and digital learning platforms. These approaches are found to enhance student engagement, understanding, and skills acquisition by offering interactive and learner-centered instructional experiences. However, variations in instructional delivery are observed across teachers, attributable to differences in their individual access to technology and levels of digital proficiency. Such variation points to the need for consistent pedagogical support and structured guidance on effective technology-based teaching strategies. The data imply that while technology-supported delivery positively shapes student engagement and skills development, inconsistencies driven by uneven access and proficiency may produce unequal learning outcomes. Standardized instructional frameworks, continuous pedagogical training, and equitable access to instructional technologies are therefore critical measures for ensuring uniformity in the quality of TLE instruction across schools.

Resource availability

The availability of technological resources across schools is found to be generally adequate but unevenly distributed. Most schools possess basic ICT equipment, including computers, projectors, and internet connectivity, sufficient to support technology-integrated TLE instruction at a foundational level. Limitations persist, however, with respect to advanced tools, specialized software, and well-maintained laboratories, and these constraints restrict the full realization of hands-on, technology-driven learning experiences. These conditions underscore the importance of sustained investment, proper maintenance protocols, and equitable resource allocation to strengthen technology integration across all schools. Addressing these resource gaps is essential to ensuring that all learners benefit equally from modern, industry-aligned instructional environments.

Teacher competency

Teacher competency in technology integration is generally high, particularly among respondents who have engaged in relevant professional development and training programs. Teachers demonstrate confidence in using digital tools for lesson planning, instruction, and assessment. Notwithstanding, gaps in advanced technological skills and in the application of emerging instructional technologies persist, most notably among less experienced educators. These findings affirm that professional development initiatives have broadly succeeded in building teachers' digital competencies, while simultaneously revealing the need for ongoing capacity-building, differentiated mentoring, and upskilling programs that target both foundational and advanced levels of technological and pedagogical proficiency. Strengthening these competencies will enable educators to adopt innovative instructional approaches and respond effectively to the evolving demands of TLE in a technology-driven economy.

Administrative support

Administrative support is identified as a critical enabling factor for technology integration in TLE instruction. School administrators are found to provide policy direction, encourage technology use, and facilitate teacher development through training opportunities and resource allocation. Despite these positive contributions, budget constraints and competing institutional priorities affect the consistency and sustainability of administrative support. These findings imply that while leadership practices generally promote technology use, their impact is constrained by structural and financial limitations. Strengthening administrative commitment through clear strategic planning, dedicated funding streams, and robust monitoring and evaluation mechanisms is essential to institutionalize technology integration and ensure its long-term consistency, effectiveness, and sustainability across schools.

Identified technical requirements for effective technology integration in TLE instruction

Effective technology integration in TLE instruction is contingent upon the availability and proper implementation of several key technical requirements. The study identifies these requirements under five interrelated dimensions: SDG alignment, hardware, software, internet connectivity, and technical support systems.

Regarding SDG alignment, the integration of technology in TLE instruction is found to support SDG 4 (Quality Education) by enhancing learning outcomes, and SDG 9 (Industry, Innovation, and Infrastructure) by developing students' technical and innovative capabilities. This alignment implies that schools engaged in technology-integrated TLE instruction are simultaneously advancing both the quality and the relevance of education, preparing students to contribute actively to sustainable development and a knowledge-based economy. This underscores the need for continuous investment in digital tools, teacher training, and curriculum updates as drivers of SDG-focused educational practice.

With respect to hardware, the findings confirm that essential devices, including computers, tablets, projectors, and other digital equipment, constitute a foundational technical requirement for effective TLE instruction. The availability of these devices ensures that technology-integrated instruction can be delivered meaningfully, enhancing student engagement, practical skill development, and hands-on learning. Schools must therefore prioritize the investment in and maintenance of adequate digital hardware to support sustainable, high-quality education aligned with 21st-century learning competencies.

On the dimension of software, technology-integrated TLE instruction is found to rely on educational software, applications, and digital platforms to deliver interactive, competency-based learning experiences. Access to relevant and regularly updated software is identified as essential for effective technology integration and for the cultivation of 21st-century competencies in TLE, particularly in areas of creativity, digital skills, and technical proficiency.

Internet connectivity is similarly identified as a critical requirement, with reliable access enabling online learning, digital collaboration, and timely access to up-to-date instructional resources. Consistent internet connectivity ensures the seamless delivery of technology-integrated TLE instruction and supports the collaborative learning experiences that are central to developing 21st-century competencies.

Finally, the availability of ongoing technical support is found to be indispensable for sustaining the effective operation of hardware, software, and connectivity infrastructure. Effective technical support systems minimize instructional disruptions, maintain operational continuity, and contribute to the development of students' technical proficiency and 21st-

century competencies by ensuring that the technological ecosystem supporting TLE instruction remains functional and reliable.

Level of technology integration in TLE in promoting sustainable learning outcomes and 21st-Century competencies

The overall level of technology integration in TLE, as perceived by the 142 respondents, is rated High, with an aggregate mean of 3.87 and a standard deviation of 0.72, corresponding to an overall agreement rate of 77.3%. An examination of individual indicators reveals nuanced variation across the dimensions assessed. The use of digital tools to enhance students' critical thinking and problem-solving skills receives the highest mean rating of 4.20 ($SD = 0.65$), with 42 respondents or 84% of the sample rating this indicator as agree or strongly agree, yielding a High interpretation. The integration of technology to promote collaboration and communication among students is rated at a mean of 4.00 ($SD = 0.70$), with 40 respondents or 80% agreeing, also interpreted as High. The use of digital platforms to support self-directed and lifelong learning is rated at a mean of 3.90 ($SD = 0.68$), with 39 respondents or 78% in agreement, likewise interpreted as High. The effective use of technology to develop creativity and innovation in TLE projects receives a mean of 3.80 ($SD = 0.75$), with 38 respondents or 76% agreeing, producing a Moderate to High interpretation. The application of technological skills aligned with real-world and industry practices yields a mean of 3.70 ($SD = 0.72$), with 37 respondents or 74% in agreement, also interpreted as Moderate to High. The lowest-rated indicator pertains to technology integration fostering understanding of sustainable practices in alignment with SDG 4 and SDG 9, with a mean of 3.60 ($SD = 0.78$), 36 respondents or 72% agreeing, and a Moderate to High interpretation. The high overall mean of 3.87 indicates that digital tools and platforms are effectively enhancing critical thinking, collaboration, creativity, and practical skills among TLE learners, and that instruction is broadly aligned with SDG 4 and SDG 9. However, the Moderate to High ratings on three indicators, specifically those relating to creativity and innovation, real-world skill application, and SDG-oriented sustainable practices, highlight persistent areas where further professional development, equitable technology access, and continuous curriculum updating are needed to fully maximize the benefits of technology integration for all learners.

Level of effectiveness of technology-integrated TLE instruction

The overall level of effectiveness of technology-integrated TLE instruction is rated High, with an aggregate mean of 4.06, a standard deviation of 0.68, and an overall agreement frequency of 203 respondents representing 81.2% of the sample. Individual indicators further illuminate the dimensions of this effectiveness. The first indicator, that TLE instruction enhances students' technical-vocational skills through technology integration, receives the highest mean of 4.30 ($SD = 0.62$), with 43 respondents or 86% rating it as agree or strongly agree, interpreted as High. The second indicator, that technology-integrated TLE promotes students' creativity in project development and problem-solving, yields a mean of 4.10 ($SD = 0.68$), with 41 respondents or 82% in agreement, also interpreted as High. The fifth indicator, that technology-enhanced instruction improves students' ability to apply theoretical knowledge in practical, real-world scenarios, receives a mean of 4.20 ($SD = 0.65$), with 42 respondents or 84% agreeing, interpreted as High. The third indicator, that students demonstrate innovation and originality in TLE outputs due to the use of digital tools, is rated at a mean of 3.90 ($SD = 0.71$), with 39 respondents or 78% in agreement, yielding a High interpretation. The lowest-rated indicator concerns the extent to which technology integration increases students' awareness and practice of sustainable and environmentally friendly methods, receiving a mean

of 3.80 (SD = 0.73), with 38 respondents or 76% agreeing, producing a Moderate to High interpretation. The aggregate mean of 4.06 affirms that students are successfully developing technical-vocational skills, creativity, innovation, and environmental awareness through technology-integrated TLE instruction, and that the integration of digital tools and platforms is enriching practical learning experiences while preparing learners for real-world application. The single Moderate to High rating, that pertaining to environmental awareness, identifies a specific area warranting enhanced instructional attention, including more deliberate embedding of sustainability-oriented content within technology-integrated TLE lessons. Sustained improvement in instructional strategies, access to advanced technologies, and targeted professional development for teachers remain necessary to consolidate and further advance the overall effectiveness of TLE instruction.

Significant relationship between respondents' profile and their perception of the effectiveness of technology integration in TLE instruction

A one-way ANOVA was conducted to examine whether respondents' age group, gender, teaching experience, and educational attainment significantly influenced their perception of the effectiveness of technology-integrated TLE instruction toward SDG alignment. The results reveal statistically significant effects for two profile variables and non-significant effects for the remaining two.

With respect to age group, the ANOVA yields an F-value of 4.21 with a corresponding p-value of 0.021, a between-groups sum of squares of 5.12 across 2 degrees of freedom (mean square = 2.56), and a within-groups sum of squares of 29.38 across 47 degrees of freedom (mean square = 0.625), with a total sum of squares of 34.50 across 49 degrees of freedom. Since the p-value of 0.021 falls below the alpha level of 0.05, the null hypothesis is rejected, indicating a statistically significant difference in perception across age groups. This finding suggests that respondents' maturity and generational experiences with technology meaningfully shape how they assess the effectiveness of technology-integrated TLE instruction in advancing SDG-aligned outcomes. Older or more mature respondents may bring a more tempered or historically grounded evaluative lens, whereas younger respondents may be more naturally oriented toward digital instructional modalities.

Regarding gender, the ANOVA produces a between-groups sum of squares of 0.82 with 1 degree of freedom (mean square = 0.82) and a within-groups sum of squares of 33.68 across 48 degrees of freedom (mean square = 0.702), yielding an F-value of 1.15 and a p-value of 0.289, with a total sum of squares of 34.50 across 49 degrees of freedom. As the p-value of 0.289 exceeds the alpha level of 0.05, the null hypothesis is retained, indicating no statistically significant difference in perception between male and female respondents. This result implies that gender does not substantially influence how educators and administrators perceive the effectiveness of technology integration, suggesting that efforts to enhance technology integration in TLE can be applied broadly across both sexes without gender-specific differentiation.

For teaching experience, the ANOVA yields a between-groups sum of squares of 4.75 across 2 degrees of freedom (mean square = 2.38) and a within-groups sum of squares of 29.75 across 47 degrees of freedom (mean square = 0.633), resulting in an F-value of 3.92 and a p-value of 0.026, with a total sum of squares of 34.50 across 49 degrees of freedom. The p-value of 0.026, being less than 0.05, leads to rejection of the null hypothesis, confirming a statistically significant difference in perception across experience levels. This result implies that the depth of professional exposure meaningfully affects how educators appraise the effectiveness of

technology-integrated TLE instruction. Respondents with more extensive teaching experience may evaluate the practical outcomes of technology use through a more rigorous or context-aware framework informed by years of direct classroom observation, while those with fewer years of experience may evaluate effectiveness with greater enthusiasm and optimism toward digital tools.

With respect to educational attainment, the ANOVA produces a between-groups sum of squares of 1.92 across 2 degrees of freedom (mean square = 0.96) and a within-groups sum of squares of 32.58 across 47 degrees of freedom (mean square = 0.693), yielding an F-value of 1.45 and a p-value of 0.242, with a total sum of squares of 34.50 across 49 degrees of freedom. The p-value of 0.242 exceeds 0.05, resulting in retention of the null hypothesis and indicating no statistically significant difference in perception across educational attainment levels. This finding suggests that the academic degree held by a respondent does not substantially differentiate their perceptions of the effectiveness of technology integration, implying that interventions aimed at improving technology use in TLE do not require differentiation based on formal educational credentials.

Collectively, the significant effects of age group and teaching experience on perceived effectiveness indicate that maturity and professional exposure are meaningful moderators of how educators evaluate technology-integrated TLE instruction, underscoring the need for differentiated professional development and mentorship programs that are sensitive to varying experience levels and generational contexts. The non-significant results for gender and educational attainment, conversely, confirm that technology integration initiatives can be implemented with broad, inclusive approaches across these dimensions, without the need for targeted stratification based on sex or degree attainment.

CONCLUSION

This chapter presents a synthesis of the study's key findings, interpretive insights, and recommendations arising from the investigation into the integration and effectiveness of technology in Technology and Livelihood Education (TLE) instruction, with particular attention to its alignment with Sustainable Development Goal 4 (Quality Education) and Sustainable Development Goal 9 (Industry, Innovation, and Infrastructure). The discussion draws together evidence gathered from 140 respondents to construct a coherent and reflective account of how technology-enhanced TLE instruction shapes student learning outcomes, fosters 21st-century competencies, and responds to the demands of an increasingly digitized and sustainability-oriented global workforce.

The study established that effective technology integration in TLE depends fundamentally on the availability and proper functioning of essential technical resources, including hardware such as computers, tablets, and projectors, as well as appropriate software, reliable internet connectivity, and responsive technical support systems. These infrastructure components were found to be necessary conditions for enhancing instructional delivery and sustaining meaningful student engagement. Where these resources were adequately provisioned, the quality and consistency of technology-supported learning were demonstrably strengthened, underscoring the importance of deliberate investment in physical and digital infrastructure as a prerequisite for realizing the broader instructional goals of TLE programs.

With respect to the level of technology integration, the findings indicated a high overall rating, reflected in a mean score of 3.87, signifying that TLE instruction effectively supports critical thinking, collaboration, creativity, and real-world skill application among students. This result affirms that technology has been meaningfully embedded into instructional practice rather than serving merely as a supplementary resource. However, specific areas related to fostering students' understanding of sustainable practices received moderate-to-high ratings,

revealing that while integration is generally strong, targeted improvements remain necessary to fully realize the potential of technology as a vehicle for sustainability education within the TLE context.

The effectiveness of technology-integrated TLE instruction was similarly rated high, with an overall mean of 4.06, indicating that technology-enhanced approaches successfully develop students' technical-vocational skills, creativity, innovation, and environmental awareness. These outcomes affirm the capacity of well-implemented technology integration to produce the kind of multidimensional, future-oriented competencies that both SDG 4 and SDG 9 envision for learners in the 21st century. Nevertheless, moderate-to-high ratings in areas related to the application of sustainable and environmentally-friendly practices suggest that further curricular and pedagogical refinement is warranted, particularly in embedding sustainability not as an ancillary theme but as an integral dimension of all TLE modules and learning activities.

Regarding the relationship between respondents' demographic profiles and their perceptions of technology effectiveness, the analysis revealed that age and teaching experience exert a statistically significant influence on how respondents perceive the effectiveness of technology integration, with p values falling below the 0.05 alpha level. These findings suggest that educators at different career stages and life phases bring meaningfully different orientations to technology use in the classroom, and that professional development initiatives must be calibrated to account for these experience-related and age-related differences. In contrast, gender and educational attainment were not found to significantly affect perception, indicating that integration strategies hold broad applicability across diverse teacher profiles and that targeted differentiation along these dimensions is less critical.

Taken together, these findings support the conclusion that technology integration in TLE is largely effective in enhancing student learning outcomes, developing 21st-century competencies, and advancing the goals articulated in SDG 4 and SDG 9. The availability of competent teachers and adequate technical resources contributes substantially to this effectiveness. At the same time, disparities in technology access, variations in teacher proficiency, and the differential perceptions shaped by age and experience point to persistent gaps that must be addressed through purposeful and sustained institutional action. The study consequently recommends investing in modern and well-maintained hardware, software, internet infrastructure, and technical support to ensure uninterrupted and equitable technology access across all TLE classes. Regular training and mentoring programs tailored to teachers' varying levels of experience and digital proficiency are essential to strengthening both technical competence and pedagogical effectiveness. TLE curricula must be continuously updated to incorporate emerging technologies, industry-relevant competencies, and sustainable practices, and all students must be guaranteed equal access to digital tools and online learning platforms to maximize engagement and skill development. The establishment of systematic monitoring and evaluation mechanisms will enable institutions to track integration effectiveness and inform iterative improvements to instructional strategies. Finally, sustainability and innovation must be deliberately emphasized across all TLE modules to deepen alignment with SDG 4 and SDG 9 and to produce graduates who are both environmentally conscious and industry-ready.

This study makes a meaningful contribution to the growing body of scholarship on technology-enhanced vocational education by providing empirical evidence of the conditions under which technology integration yields high instructional effectiveness and by identifying the profile-related factors that mediate teachers' perceptions of that effectiveness. The proposed strategic framework for integrating technology in TLE, spanning teacher preparation,

infrastructure development, project-based learning, industry linkages, and continuous assessment, offers a practical and evidence-grounded roadmap for institutions seeking to align their programs with global sustainability and industry standards. Future research may productively extend this work by examining student-level outcomes in greater depth, exploring the long-term effects of sustained technology integration on graduates' workforce readiness, and investigating how contextual factors such as school location, resource availability, and institutional culture moderate the relationship between technology integration and learning effectiveness. Such inquiries will further strengthen the evidence base needed to guide policy and practice in TLE and related technical-vocational fields.

REFERENCES

- Alviola, S. E. S. (2025). Technological integration in TLE instruction: Bridging traditional skills and digital innovation for Industry 4.0 readiness. Cebu Technological University.
- Arcadio, R. D. (2025). Enhancing sustainable teaching through technology integration in technical and livelihood education. Cebu Technological University.
- Archival, J. N. (2025). Aligning TLE practices with the sustainable development goals: A pathway to environmental stewardship and social responsibility. Cebu Technological University.
- Brundtland Commission. (1987). Our common future. Oxford University Press.
- Capote, R. S. (2025). Technology-driven instruction for creativity and productivity in TLE education. Cebu Technological University.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340.
- Fullan, M. (2015). The new meaning of educational change. Teachers College Press.
- Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.
- Lumbab, J. S. (2025). Fostering green innovation through technology-integrated TLE instruction. Cebu Technological University.
- Medio, G. J. (2025). Integrating sustainability in skill-based education through technology-driven TLE instruction. Cebu Technological University.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.
- Pajaron, G. P. (2025). Challenges in the implementation of technology integration in TLE: Toward sustainable educational frameworks. Cebu Technological University.
- Selwyn, N. (2016). *Education and technology: Key issues and debates*. Bloomsbury.
- UNESCO. (2023). *Reimagining education for a sustainable future*. UNESCO Publishing.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wang, L., & Xu, C. (2022). Emerging technologies in vocational education: Enhancing employability and innovation in the digital era. *Journal of Technical Education and Training*, 14(3), 22–35.