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Harnessing TVET for New Literacies: An Experimental Study on Enhancing 21st Century Competencies

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Abstract. This study examined how integrating Technical-Vocational Education and Training (TVET) enhances new literacies and 21st-century skills among Bachelor of Technology and Livelihood Education (BTLEd) students. Guided by selected Course Learning Outcomes (CLOs), the research focused on three areas: (1) applying digital, media, and information literacy in instructional design, (2) using critical thinking, creativity, collaboration, and communication in teaching strategies, and (3) developing learning resources and assessment tools that promote higher-order thinking, responsible digital citizenship, and lifelong learning. Using a proper experimental design, the researchers randomly assigned 60 third-year BTLEd students into an experimental group with TVET-based instruction and a control group with traditional instruction. Quantitative results showed that the experimental group significantly outperformed the control group in all CLOs, demonstrating enhanced digital competence, application of the 4Cs, and production of high-quality learning materials. Qualitative insights revealed that TVET encouraged practical problem-solving, technological fluency, teamwork, and social responsibility. The study confirms that TVET effectively prepares pre-service teachers for 21st-century classrooms, equipping them with the skills, confidence, and adaptability needed to navigate complex learning environments and contribute meaningfully to lifelong learning and professional practice in a knowledge-driven society.

Keywords: TVET; new literacies; 21st-century skills; higher-order thinking; digital citizenship

1. Introduction

The 21st century has transformed education through digital technologies, globalization, and the growing demand for lifelong learning. Literacy now extends beyond reading and writing to include the ability to navigate, interpret,

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and create knowledge across digital, media, and information platforms (Leu et al., 2022; Dai, 2024). Learners face complex digital and multimodal environments, which require schools to integrate new literacies that cultivate 21st-century competencies such as critical thinking, creativity, collaboration, and communication (Trilling & Fadel, 2021; Celume & Maoulida, 2022).

Teacher education plays a central role in fostering these competencies. Pre-service teachers must develop digital literacy, technological pedagogical content knowledge (TPACK), and adaptive instructional strategies to meet the demands of modern classrooms (Misra, 2023; Aslan et al., 2025). Research shows that blended problem-based learning, ethnoscience integration, differentiated instruction, and innovative assessment enhance higher-order thinking and support inclusive education (Williams, 2021; Alawad, 2024; Fitria et al., 2025).

Technical-Vocational Education and Training (TVET) offers a transformative approach to teacher preparation by combining theory with practical experience. TVET develops practical and transversal skills, including innovation, collaboration, leadership, resilience, and lifelong learning (TESDA, 2023; Swaroopa, 2024; Baltezarević, 2025). Hands-on projects, digital simulations, and workplace problem-solving cultivate critical thinking, creativity, and social responsibility (Baldon & Codilla, 2024; Leong, 2024; Pirzada, 2020; Vimbelo & Bayaga, 2023). Leadership and policy support further strengthen TVET's impact on skill development and institutional responsiveness (Nurul Izzani et al., 2024; Mesuwini, 2024).

In the Philippines, TVET aligns with national development goals and global labor market demands (TESDA, 2023; Yusoff, 2024). Integrating TVET into teacher education equips pre-service teachers to design meaningful lessons, use technology effectively, and foster lifelong learning (Barrios, 2021; Poonputta & Nuangchalerm, 2024; Zhang, 2024). However, evidence on the impact of embedding TVET in literacy development is limited, creating a gap that this study aims to address.

Building on these insights, the present study investigates the integration of TVET into the course Building and Enhancing New Literacies Across the Curriculum for BTLEd students. Using an experimental design, it measures course learning outcomes (CLOs) and examines how TVET strengthens new literacies and cultivates essential 21st-century competencies. The study provides evidence that experiential and practice-based approaches in teacher education prepare future educators to meet contemporary classroom and workforce demand while promoting inclusive, innovative, and lifelong learning.

1.1 Theoretical Framework

This study builds on New Literacies Theory, the 21st-century Competency Framework, and experiential learning in Technical and Vocational Education and Training (TVET). New Literacies Theory explains that literacy goes beyond reading and writing. It includes digital, media, and information literacies needed in a knowledge-based society. Leu et al. (2022) state that learners must locate,

evaluate, synthesize, and share information across digital platforms. Dai (2024) emphasizes that digital literacy education develops these skills. Romero Karlsson (2024) demonstrates that engaging with multimodal texts enhances critical thinking and expands literacy practices in teacher education. This theory supports the study's goal of preparing BTLEd students to create and use knowledge in technology-rich environments.

The 21st-Century Competency Framework identifies critical thinking, creativity, collaboration, and communication as essential skills for life, work, and education (Trilling & Fadel, 2021). highlights the importance of intellectual independence and critical capacity in modern learning. Celume and Maoulida (2022) provide tools to measure these skills among youth. Other studies confirm that teacher education must foster these competencies through innovative teaching, differentiated learning, and authentic assessment (Alawad,2024). These perspectives guide the study in linking TVET integration with higher-order skills.

Experiential learning also grounds this study. TVET connects theory and practice through hands-on learning. It develops both technical and transferable competencies (TESDA, 2023). Researchers report that ICT tools (Baldon & Codilla, 2024), virtual simulations (Leong, 2024), and institutional leadership (Yusoff, 2024; Nurul Izzani et al., 2024) expand the role of TVET in preparing adaptable learners. Mesuwini (2024) notes that TVET students in online and hybrid settings need practice-oriented strategies. Embedding TVET in teacher education allows pre-service teachers to design lessons, use digital tools, and teach in authentic contexts. This process strengthens both new literacies and 21st-century competencies.

Together, these theories form the foundation of the study. TVET serves as the independent variable. New literacies act as the mediating construct. The 21st-century competencies—critical thinking, creativity, collaboration, and communication—serve as the dependent variables. This framework situates the study within the context of global education reform and aligns it with the Philippine goal of preparing future-ready educators.

1.2 Significance of the Study

This study is essential for teacher education, curriculum development, policymakers, students, and the broader community. In teacher education, it shows that TVET-based pedagogy helps pre-service teachers master new literacies while developing critical competencies such as creativity, collaboration, communication, and critical thinking. It equips them to design innovative, technology-enhanced lessons for modern classrooms.

In curriculum development, the study demonstrates how to align course learning outcomes with practice-based and skills-oriented approaches. This alignment enhances relevance, fosters lifelong learning, and cultivates responsible digital citizenship. For policymakers and practitioners, the study offers a model for integrating TVET into higher education. The evidence can guide curriculum

reform, teacher training, and institutional policy to ensure education meets both global and local demands.
For students, TVET builds future-ready skills such as adaptability, employability, and resilience. It gives them confidence to apply theory in real-life settings, which strengthens their competitiveness in the labor market. For communities, especially in the Philippines, TVET serves as an educational tool for social mobility, entrepreneurship, and nation-building.

The study also aligns with the United Nations Sustainable Development Goals (SDGs). It supports SDG 4 (Quality Education) by promoting inclusive and equitable learning through the integration of TVET. It contributes to SDG 8 (Decent Work and Economic Growth) by preparing employable and lifelong learners. It addresses SDG 9 (Industry, Innovation, and Infrastructure) by fostering innovation in education. It advances SDG 10 (Reduced Inequalities) by providing diverse learners with access to skills that enhance employability. Thus, the study adds to academic discourse and promotes inclusive and sustainable development.

1.3 Conceptual Framework

This study assumes that TVET in teacher education provides authentic, practice-oriented learning that strengthens new literacies and 21st-century skills. TVET emphasizes experiential and contextualized learning that connects theory and practice (TESDA, 2023). In teacher education, it allows pre-service teachers to engage in applied projects, technology-based learning, and skills-focused tasks beyond traditional lectures (Baldon & Codilla, 2024; Leong, 2024). TVET directly develops new literacies. It teaches students to navigate digital platforms, evaluate information, and communicate across multimodal channels (Leu et al., 2022; Dai, 2024). These literacies are essential in today's knowledge-driven, technology-based society (Romero Karlsson, 2024).

The 21st-Century Competency Framework identifies four key skills: critical thinking, creativity, collaboration, and communication. Critical thinking enables students to analyze, evaluate, and solve problems effectively. Creativity encourages innovation and the generation of new ideas. Collaboration enables teamwork across digital and cultural spaces. Communication enables learners to express their ideas clearly in various forms, including oral, written, visual, and digital (Trilling & Fadel, 2021; Celume & Maoulida, 2022). Together, these competencies foster adaptability, lifelong learning, and success in changing environments.

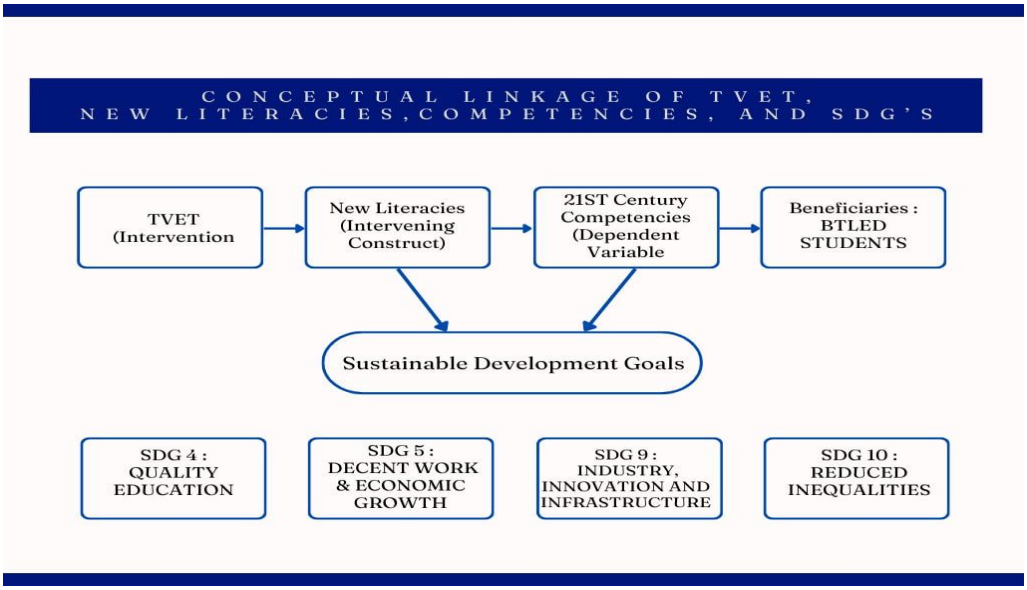

Figure 1: Schematic Diagram of the Study

1.4 Research Problem and Research Questions

1.4.1 Research Problem

The rapid evolution of digital technologies and the growing demand for 21st-century competencies necessitate that pre-service teachers possess more than foundational knowledge. They must also develop advanced skills in digital, media, and information literacy, as well as critical thinking, creativity, collaboration, and effective communication. Traditional teaching methods may not fully prepare students to meet these demands.

Therefore, researchers need to examine how integrating Technical-Vocational Education and Training (TVET) into teacher education affects students' performance in these competencies. They also need to assess their impact on students' higher-order thinking, as well as the quality of learning resources and assessment tools. Understanding the effects of TVET integration can provide valuable insights into improving the preparation of pre-service teachers for the demands of modern education.

1.4.2 Research Questions

1. What is the students' performance in digital, media, and information literacy before and after TVET integration?
2. To what extent do students apply critical thinking, creativity, collaboration, and communication in instructional strategies before and after the integration of TVET?
3. What is the quality of learning resources and assessment tools developed under TVET-based instruction compared to traditional methods?
4. How does TVET integration contribute to the overall attainment of 21st-century competencies among pre-service teachers?

2. Literature Review

2.1 21st-Century Competencies and New Literacies

The 21st century has transformed education, requiring learners to develop competencies beyond traditional literacy. These include critical thinking, creativity, collaboration, communication, and digital, media, and information literacies (Leu et al., 2022; Dai, 2024; Trilling & Fadel, 2021). Modern learners navigate complex digital and multimodal environments, making it essential for schools to integrate new literacies that prepare students for global citizenship and workforce readiness.

2.2 Teacher Preparation and Pedagogical Strategies

Teacher education plays a key role in developing 21st-century skills. Pre-service teachers require digital literacy and technological pedagogical content knowledge (TPACK) to meet the demands of modern classrooms (Misra, 2023). Blended problem-based learning, ethnoscience integration, differentiated instruction, and innovative assessments enhance higher-order skills and support inclusive learning (Williams,2021, & Alawad, 2024). Teachers act as the first mediators of literacy, designing lessons, selecting materials, and guiding students in interpreting information (Zhang, 2024; Romero Karlsson, 2024; Williams, 2021). Inquiry-based approaches, picture books, and innovative instructional designs foster critical thinking, collaboration, and problem-solving. Policy support strengthens teacher competencies through training, resources, and incentives.

2.3 Technical-Vocational Education and Training (TVET)

TVET offers a transformative approach to teacher education by combining theory with practical experience. It develops both technical and transversal skills, including creativity, collaboration, innovation, leadership, and resilience (TESDA, 2023; Swaroopa, 2024; Misra, 2023). TVET engages learners in hands-on projects, digital simulations, workplace problem-solving, and civic-oriented activities (Baldon & Codilla, 2024; Leong, 2024; Yusoff, 2024; Nurul Izzani et al., 2024). TVET helps pre-service teachers design lessons, use technology, foster digital fluency, and promote lifelong learning. It also cultivates leadership, resilience, and intellectual autonomy (Swaroopa, 2024).

2.4 Digital Literacy and Technology Integration

Digital technologies enhance teaching, engagement, and access, while experiential and project-based learning develops critical thinking, creativity, collaboration, and communication (Haleem et al., 2022; McGrath, 2023; Van Laar et al., 2020; Yudiono et al., 2022). ICT, virtual reality, and digital platforms make TVET training engaging, safe, and industry-relevant (Baldon & Codilla, 2024; Leong, 2024; Akademika, 2024). Digital literacy bridges the gap between education and industry, enabling students to adapt to the demands of the workplace. Teachers who integrate digital tools improve instruction and learner engagement, while leaders who invest in digital infrastructure expand access and foster innovation.

2.5 Coaching and Teacher Development

Coaching improves teacher practice and student outcomes. Pas et al. (2022) found that paired coaching is more cost- and time-efficient than individual coaching. Reddy et al. (2022) confirmed that instructional coaching enhances classroom practices even in resource-constrained schools. Ulbricht et al. (2024) emphasized the importance of culturally responsive interventions in strengthening teacher identity and enhancing teaching effectiveness. Coaching effectiveness depends on cost, context, and cultural responsiveness—factors that are particularly relevant for TVET programs aiming to strengthen 21st-century competencies.

2.6 Leadership, Resilience, and Specialized Skills

Leadership and resilience are essential 21st-century skills. Leadership enables learners to guide teams, make decisions, and manage conflicts. Resilience helps them adapt to change, cope with uncertainty, and recover from setbacks. Disaster management training and intellectual autonomy further develop responsibility, critical judgment, and innovation (Swaroopa, 2024; Misra, 2023). TVET offers learners opportunities to practice these skills through projects, group tasks, and workplace simulations.

2.7 Global TVET Context and Policy Implications

TVET systems worldwide face both strengths and weaknesses. Some adopt innovations quickly, while others struggle with resources and policies (Mesuwini, 2024; Said et al., 2020). Leadership shapes institutional responses, enabling the effective use of technology, collaboration, and innovation. ICT, VR, and digital tools enhance engagement and skill acquisition, but unequal access limits inclusion (Baldon & Codilla, 2024; Leong, 2024). Policymakers and organizations, such as the World Bank, emphasize TVET as a bridge to youth employment, social integration, and lifelong learning. Strong TVET systems reduce inequality and prepare learners for rapidly changing workplaces.

2.8 TVET and 21st-Century Skills

TVET plays a critical role in equipping learners with 21st-century skills. Pirzada (2020) reported that teachers in Pakistan perceive TVET as essential for promoting digital, social, and cognitive competencies. Similarly, Vimbelo and Bayaga (2023) emphasized that humanising pedagogy in South African TVET colleges enhances teaching and learning by fostering critical thinking and collaboration. TVET lecturers' engagement in work-integrated learning further strengthens these skills by providing practical, real-world experiences (Mesuwini & Mokoena, 2023).

2.9 Teaching Competencies for 21st-Century Learners

Developing teaching competencies is vital for 21st-century education. Misra (2023) argued that teachers must integrate digital, cognitive, and social-emotional skills into instruction. Barrios (2021) highlighted that teaching competencies, including adaptive instruction and learner-centered strategies, enhance students' critical thinking and problem-solving skills. Poonputta and Nuangchalerm (2024) proposed a framework to enhance primary school teachers' competencies, with a focus on creativity, communication, and collaboration.

2.10 Leadership and Institutional Support in TVET

Leadership in TVET institutions has a significant impact on skill development. Ismail and Tuan Mohd Yasin (2020) noted that leadership style shapes curriculum implementation and teacher performance. A systematic review by Nurul Izzani et al. (2024) confirmed that visionary leadership enhances institutional effectiveness and promotes 21st-century skills among learners.

2.11 Cognitive, Social, and Emotional Competencies

Developing cognitive, social, and emotional skills is essential for holistic education. Maoulida, Madhukar, and Celume (2023) demonstrated that online learning environments foster these competencies, including self-regulation and collaboration. Eneng (2023) linked vocational education to citizenship skills, showing that 21st-century competencies extend beyond technical knowledge to ethical and civic responsibility.

2.12 Digital Literacies and AI Integration

Digital literacies and AI are becoming central to 21st-century competencies. Chen (2023) highlighted the role of generative AI in enhancing students' new literacies. Owais and Taym (2024) found that AI tools, including ChatGPT, improve learners' writing, critical thinking, and research skills. Ponce (2024) emphasized that AI literacies depend on users' prompt confidence, which influences learning outcomes and professional competencies. South African TVET students reported both opportunities and challenges in online learning, highlighting the importance of digital readiness (Mesuwini, 2024).

2.13 Regional Context and Application

Research from Pakistan, Thailand, and South Africa confirms that context-specific strategies improve 21st-century competency development. Pirzada (2020) showed that local perceptions shape TVET adoption in Pakistan. Poonputta and Nuangchalerm (2024) stressed the need for tailored frameworks in Thailand. Vimbelo and Bayaga (2023) demonstrated that culturally responsive pedagogy enhances the effectiveness of TVET in South Africa.

2.14 Synthesis

TVET effectively develops 21st-century competencies by combining practical, digital, cognitive, social, and emotional skills, preparing learners for complex, globalized, and technology-driven environments. It enhances critical thinking, creativity, communication, collaboration, and digital literacies through hands-on, problem-based, and AI-integrated learning (Leu et al., 2022; Chen, 2023; Trilling & Fadel, 2021; Owais & Taym, 2024).

Teacher preparation, innovative pedagogical strategies, and coaching strengthen these competencies, while leadership and policy support ensure effective curriculum implementation and institutional readiness (Misra, 2023; Nurul Izzani et al., 2024; Pas et al., 2022). TVET also cultivates resilience, leadership, and socially responsible behaviors, linking education with workplace demands and citizenship skills (Swaroopa, 2024; Eneng, 2023; Vimbelo & Bayaga, 2023).

Digital technology integration, AI literacy, and culturally responsive approaches further enhance engagement, inclusion, and lifelong learning (Haleem et al., 2022;

Baldon & Codilla, 2024; Mesuwini, 2024). Research across Pakistan, Thailand, and South Africa confirm that context-specific and experiential TVET strategies prepare learners to navigate rapidly changing environments, meet global workforce requirements, and contribute meaningfully to sustainable development goals (Pirzada, 2020; Poonputta & Nuangchalerm, 2024).

3. Methodology

3.1 Research Design

This study employed a proper experimental design with pre-test and post-test control groups to assess the impact of TVET integration on students' competencies. The researchers randomly assigned students to the experimental and control groups to reduce bias and strengthen validity. The design allowed a clear comparison between students who received TVET-based instruction and those who experienced traditional methods. This setup enabled the direct linking of differences in literacy and competency to the intervention.

3.2 Participants

Sixty third-year BTLEd students from the College of Education joined the study. All students were enrolled in the course Building and Enhancing New Literacies Across the Curriculum. The researchers randomly assigned thirty students to the experimental group and thirty to the control group. The experimental group received TVET-based instruction, while the control group received lecture-discussion instruction. This setup ensured that both groups were equal in academic level and background, making the results more reliable.

3.3 Instruments

The researchers used three instruments to collect data. The New Literacies Performance Test measured students' digital, media, and information literacy skills. The 21st Century Skills Rubric assessed critical thinking, creativity, collaboration, and communication. The Learning Resource and Assessment Evaluation Tool assessed the quality of instructional materials and assessments, with a focus on higher-order thinking, digital citizenship, and lifelong learning. Experts validated the instruments, and tests confirmed their reliability.

3.4 Procedure

The researchers followed a structured procedure in applying the intervention. The experimental group received TVET-based instruction with digital storytelling, multimedia lesson design, and project-based collaboration. This method encouraged active learning and real-world application of knowledge. The control group received traditional lecture-discussion using text-based resources, with limited use of digital tools. Both groups took pre-tests before the intervention and post-tests after the intervention. Trained raters independently evaluated student outputs to ensure fairness and objectivity.

3.5 Data Analysis

The researchers analyzed the data using descriptive and inferential statistics. They applied paired-sample t-tests to measure improvement within each group and independent-sample t-tests to compare the two groups. They also calculated inter-rater reliability, which produced a Cronbach's alpha of 0.86, showing high

reliability. This statistical treatment and reliability check strengthened the accuracy of the findings.

3.6 Ethics Considerations

The study adhered to ethical standards in educational research to ensure that the rights, safety, and well-being of all participants were protected. Before data collection, formal approval was obtained from the Institutional Ethics Review Committee. Parental consent and student assent were secured for all participants below the age of 18, with clear explanations provided regarding the study's objectives, procedures, potential risks, and benefits. Participation was voluntary, and students were informed of their right to withdraw at any point without penalty.

Data privacy and confidentiality were strictly maintained by anonymizing all personal information and storing digital records on password-protected systems accessible only to the research team. For AI-based platforms, only non-identifiable student accounts were used, and usage data were monitored in compliance with institutional data protection policies. The researchers ensured that the use of AI tools posed no psychological harm or academic disadvantage to participants. Additionally, care was taken to avoid introducing bias in the control and experimental groups, promoting fairness and academic integrity throughout the study.

4. Results

Table 1: Pre-test and Post-test Scores in New Literacies Performance

Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Gain	*t*-value	*p*-value
Experimental	30	74.3 (6.2)	89.4 (5.3)	+15.1	6.12	<0.001***
Control	30	73.9 (6.0)	78.6 (6.1)	+4.7	1.82	0.074

$p < 0.001$, highly significant

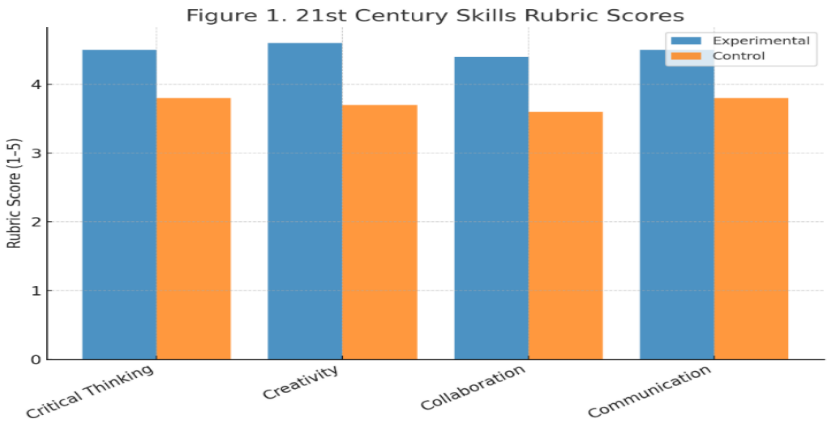

Figure 2: 21st Century Skills Rubric Scores

Table 1 and the graph show pre- and post-test performance in new literacies. Both groups started with similar scores (experimental: M = 74.3, SD = 6.2; control: M = 73.9, SD = 6.0). After the intervention, the experimental group showed a significant improvement to M = 89.4 (SD = 5.3), t (58) = 6.12, $p < 0.001$, while the control group exhibited a smaller, non-significant increase to M = 78.6 (SD = 6.1), t = 1.82, p = 0.074. The graph shows a steep rise for the experimental group and a slight rise for the control group, highlighting the strong effect of TVET-based instruction.

Table 2: Comparison of 21st Century Skills Rubric Scores

Skills Dimension	Experimental Mean	Control Mean	Mean Difference	Remarks
Critical Thinking	4.5	3.8	+0.7	Significant
Creativity	4.6	3.7	+0.9	Significant
Collaboration	4.4	3.6	+0.8	Significant
Communication	4.5	3.8	+0.7	Significant

Ratings based on a 5-point rubric scale

Table 2 and the pie graphs show that the experimental group scored higher than the control group in all 21st-century skills: critical thinking (4.5 vs. 3.8), creativity (4.6 vs. 3.7), collaboration (4.4 vs. 3.6), and communication (4.5 vs. 3.8). The results demonstrate that TVET-based instruction effectively enhances these skills.

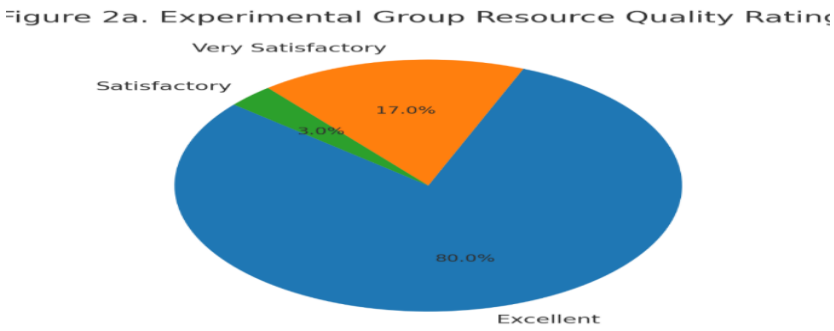

Figure 3: Experimental Group Resource Quality Rating

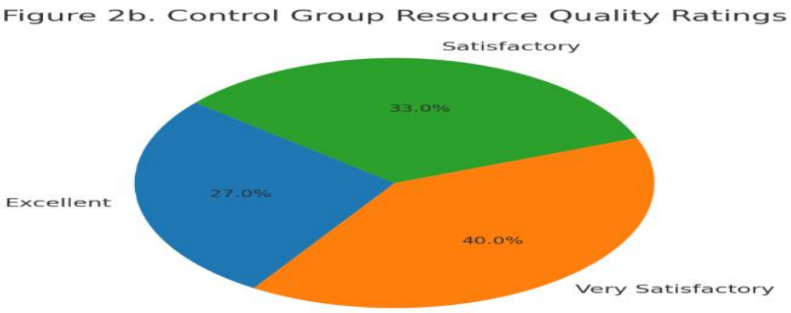

Figure 4: Control Group Resource Quality Ratings

Table 3: Quality Ratings of Learning Resources and Assessments

Rating Category	Experimental Group (n=30)	Control Group (n=30)
Excellent	24 (80%)	8 (27%)
Very Satisfactory	5 (17%)	12 (40%)
Satisfactory	1 (3%)	10 (33%)
Needs Improvement	0	0

Table 3 and the bar graph show that 80% of the experimental group rated learning resources as Excellent, compared to 27% of the control group. The control group gave more Very Satisfactory and Satisfactory ratings. These results indicate that TVET-based instruction produced more engaging, practical, and learner-centered resources.

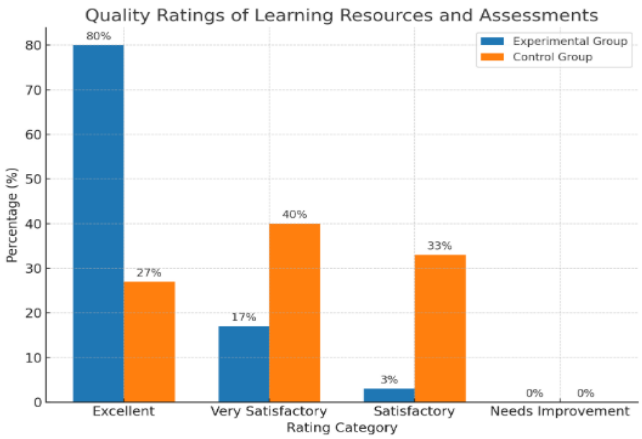

Figure 5: Quality Ratings of Learning and Assessments

Table 3 and the bar graph show that 80% of the experimental group rated learning resources as Excellent, compared to 27% of the control group. The control group gave more Very Satisfactory and Satisfactory ratings. These results indicate that TVET-based instruction produced more engaging, practical, and learner-centered resources.

5. Discussion of Findings

The study confirms that TVET improves students' attainment of CLOs in Building and Enhancing New Literacies Across the Curriculum. The experimental group outperformed the control group in digital, media, and information literacy. This aligns with Leu et al. (2022), who argue that 21st-century literacy involves reading, writing, navigating, and evaluating multimodal texts on digital platforms.

Similarly, Chen (2023) and Owais and Taym (2024) emphasize that engagement with digital tools and AI enhances students' critical evaluation and information

management skills. TVET enables learners to source, analyze, and apply knowledge in authentic contexts, supporting Beers' (2022) assertion that education must meet the demands of a rapidly changing knowledge economy.
Students demonstrated frequent use of the **4Cs—critical thinking, communication, collaboration, and creativity—**during TVET-based instruction. Experiential and problem-based activities cultivated higher-order thinking (Trilling & Fadel, 2021). Hands-on projects promoted teamwork and innovation, improving both academic performance and workplace readiness (Fitria, Asrizal, & Lufri, 2025; Fadel et al., 2019). These findings align with studies in TVET contexts, which show that applied, student-centered learning enhances cognitive, social, and emotional competencies (Maoulida, Madhukar, & Celume, 2023; Vimbelo & Bayaga, 2023).

The experimental group also produced higher quality learning resources, indicating that TVET fosters authentic, socially responsible teaching. This aligns with TESDA's (2023) vision of globally competitive graduates with industry-relevant skills and lifelong learning habits. The results further support UNESCO's (2023) advocacy for aligning TVET with the Sustainable Development Goals, highlighting its role in promoting inclusion, equity, and employability.

5.1 Expanded Qualitative Insights

Theme 1: Practical Problem-Solving and Critical Thinking

TVET's hands-on activities encouraged flexibility and creative problem-solving. Students reported feeling empowered, noting experiences like "figuring out solutions on my own rather than relying solely on textbooks." This reflects enhanced critical thinking and aligns with research demonstrating that experiential TVET activities improve adaptive instructional design and problem-solving (Poonputta & Nuangchalerm, 2024; Yudiono et al., 2022).

Theme 2: Technological Literacy and Digital Competence

Engagement with TVET exposed pre-service teachers to digital tools and educational technologies. Students reported increased confidence in using unfamiliar platforms, demonstrating growth in technological literacy. This finding aligns with those of Aslan, Alanoğlu, and Karabatak (2024), Haleem et al. (2022), and Misra (2023), who emphasize that digital competence is essential for effective 21st-century teaching. Chen (2023) and Owais and Taym (2024) further highlight that integrating AI and digital platforms enhances both technical fluency and pedagogical innovation.

Theme 3: Collaboration and Interpersonal Skills

Group-based TVET projects strengthened teamwork, communication, and leadership. Students reflected on experiences such as "learning to listen to my peers' ideas and negotiate solutions together," demonstrating improved interpersonal skills. Literature confirms that collaborative TVET projects prepare learners for professional teamwork in diverse educational settings (Mesuwini & Mokoena, 2023; Pas et al., 2022; Urazova, 2024).

5.2 Synthesis of Quantitative and Qualitative Findings

Thematic insights suggest that TVET cultivates holistic competencies beyond technical knowledge. Pre-service teachers developed confidence, adaptability, and collaboration abilities—skills critical for dynamic classroom and workplace contexts. These qualitative findings complement quantitative evidence, confirming that experiential learning in TVET effectively equips educators for 21st-century teaching (McGrath, 2023; Poonputta & Nuangchalerm, 2024; UNESCO-UNEVOC, 2021).

6. Conclusion

This study demonstrates that integrating TVET in teacher education strengthens pre-service teachers' 21st-century competencies. The experimental group outperformed the control group in digital, media, and information literacy, demonstrating that TVET enables learners to navigate, evaluate, and apply multimodal texts effectively. Students used the 4Cs—critical thinking, communication, collaboration, and creativity—through hands-on, problem-based learning, promoting innovation, teamwork, and higher-order thinking essential for academic success and workplace readiness.

TVET also improved technological literacy. Pre-service teachers gained confidence using digital tools, educational platforms, and AI applications, preparing them for modern classrooms and professional environments. Collaborative projects further enhanced interpersonal skills, including leadership, negotiation, and effective communication. These experiences fostered practical problem-solving skills, applied knowledge, and socially responsible behaviors.

The findings support global education standards emphasizing equity, inclusion, and employability. They highlight the importance of aligning teacher education with 21st-century competencies to produce adaptable, innovative, and skilled educators. Integrating TVET equips pre-service teachers with the knowledge, skills, and attitudes necessary to thrive in dynamic classrooms, respond to real-world challenges, and make meaningful contributions to sustainable development goals.

7. Recommendations

1. Integrate TVET Across Curricula

Universities and teacher education programs should embed TVET activities in all courses to enhance digital, media, and information literacy, as well as the 4Cs—critical thinking, communication, collaboration, and creativity.

2. Promote Experiential and Problem-Based Learning

Educators should design hands-on, real-world tasks that allow students to apply knowledge, solve problems, and develop higher-order skills. Such learning strengthens both academic performance and workplace readiness.

3. Enhance Digital and AI Competence

Institutions should provide training on digital tools, platforms, and AI applications to improve students' technological literacy and confidence in 21st-century learning environments.

4. Foster Collaboration and Interpersonal Skills
Teachers should implement group-based projects that encourage teamwork, negotiation, and leadership, preparing students for professional and diverse settings.

5. Align TVET with Global Standards and SDGs
Educational policymakers should ensure that TVET programs contribute to equity, inclusion, employability, and sustainable development goals, producing competent and socially responsible graduates.

6. Support Continuous Professional Development
Teacher educators should receive ongoing training in TVET pedagogy, digital literacies, and collaborative instructional strategies to maintain high-quality 21st-century teaching.

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