

ENHANCING 21ST-CENTURY COMPETENCIES THROUGH TVET-BASED INSTRUCTIONAL MATERIALS IN TEACHER EDUCATION: A QUASI-EXPERIMENTAL RESEARCH

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ABSTRACT: *The growing demand for 21st-century competencies has prompted teacher education institutions to adopt innovative instructional approaches that strengthen critical thinking, creativity, collaboration, and communication. This study investigated the effectiveness of instructional materials based on technical-vocational education and training principles in enhancing the learning performance and 21st-century competencies of Bachelor of Technology and Livelihood Education students enrolled in Introduction to Industrial Arts Part 2. A quasi-experimental pre-test–post-test control group design was employed involving students from the University of Science and Technology of Southern Philippines, Cagayan de Oro. The experimental group was taught using instructional materials that integrated hands-on learning activities, digital simulations, and collaborative tasks, while the control group received conventional lecture-discussion instruction. Data were collected using a researcher-developed learning performance test and an assessment rubric measuring critical thinking, creativity, collaboration, and communication. Descriptive statistics and paired samples t-tests were used to analyze the data. Results showed that both groups demonstrated improvements in learning performance from pre-test to post-test; however, the experimental group achieved a greater mean gain than the control group. Likewise, students exposed to the instructional materials obtained higher post-test scores across all four 21st-century competencies. The findings suggest that instructional materials grounded in technical-vocational education and training principles provide meaningful learning experiences that improve academic performance and foster essential competencies required in contemporary education. The study highlights the value of integrating experiential and practice-oriented learning strategies into teacher education programs to better prepare future educators for the evolving demands of classrooms and the workforce.*

Keywords: Technical-Vocational Education and Training (TVET), instructional materials, 21st-century competencies, critical thinking, creativity.

INTRODUCTION

The rapid advancement of digital technologies, globalization, and the transition toward knowledge-based economies have transformed educational systems worldwide. Contemporary education extends beyond the acquisition of foundational literacy skills to encompass digital, information, and media literacy, enabling learners to effectively access, evaluate, create, and communicate knowledge across diverse digital environments [1,2]. Consequently, higher education institutions are increasingly expected to prepare graduates with competencies that support lifelong learning, adaptability, innovation, and responsible participation in an evolving digital society.

Developing 21st-century competencies, including critical thinking, creativity, collaboration, and communication, has become a central goal of educational reform. These competencies are widely recognized as essential for academic success, employability, and active citizenship in rapidly changing technological and professional environments [3,4]. Educational systems are therefore encouraged to implement learner-centered instructional approaches that actively engage students in authentic, inquiry-based, and collaborative learning experiences rather than relying solely on traditional lecture-based instruction.

Teacher education institutions play a critical role in developing these competencies among future educators. Pre-service teachers must possess not only strong pedagogical knowledge but also the ability to integrate technology effectively, facilitate collaborative learning, promote critical thinking, and design meaningful learning experiences that

prepare students for contemporary classrooms. Research has shown that innovative instructional approaches, including problem-based learning, experiential learning, and technology-supported instruction, significantly enhance students' engagement, higher-order thinking skills, and learning performance [5–8].

Technical and Vocational Education and Training (TVET) provides an educational framework that effectively integrates theoretical knowledge with practical application. Through authentic workplace experiences, hands-on activities, collaborative projects, and problem-solving tasks, TVET develops both technical competencies and transferable skills that are highly valued in modern workplaces [9–12]. Experiential learning within TVET enables learners to construct knowledge through direct experience, reflection, and active participation, thereby strengthening both cognitive and practical competencies.

In the Philippines, TVET serves as a strategic component of national human resource development. The National Technical Education and Skills Development Plan (NTESDP) 2023–2028 emphasizes industry responsiveness, lifelong learning, digital transformation, and workforce readiness as priorities for strengthening technical education and enhancing graduates' employability [13]. These national priorities highlight the importance of integrating TVET principles into teacher education programs to ensure that future educators are equipped with practical competencies and innovative instructional strategies aligned with evolving educational and labor market demands.

Within teacher education, instructional materials serve as essential tools that facilitate meaningful learning experiences. Well-designed instructional materials promote active participation, collaboration, critical inquiry, and authentic assessment while supporting diverse learning needs. Studies have demonstrated that instructional materials grounded in experiential and learner-centered principles contribute to improved academic achievement, increased student engagement, and stronger development of higher-order thinking skills [6,7,14].

Despite increasing recognition of the value of TVET-oriented instructional strategies, limited empirical evidence exists regarding the effectiveness of TVET-based instructional materials in enhancing both learning performance and 21st-century competencies among Bachelor of Technology and Livelihood Education (BTLEd) students in Philippine higher education institutions. Most previous studies have focused on curriculum implementation, policy development, or workforce preparation, with relatively few quasi-experimental investigations examining instructional materials specifically designed for teacher education.

To address this gap, the present study examined the effectiveness of TVET-based instructional materials developed for the course *Introduction to Industrial Arts Part 2* among BTLEd students at the University of Science and Technology of Southern Philippines. Using a quasi-experimental pretest–posttest control-group design, the study evaluated the effects of the instructional materials on students' learning performance and four key 21st-century competencies: critical thinking, creativity, collaboration, and communication. The findings contribute empirical evidence on the role of practice-oriented instructional materials in strengthening teacher education and provide practical implications for curriculum development and instructional innovation in technical-vocational teacher education.

Conceptual Framework

This study adopts a quasi-experimental design to examine the effect of using instructional materials in *Introduction to Industrial Arts Part 2* on the development of new literacies and 21st-century competencies among BTLEd students at USTP CDO.

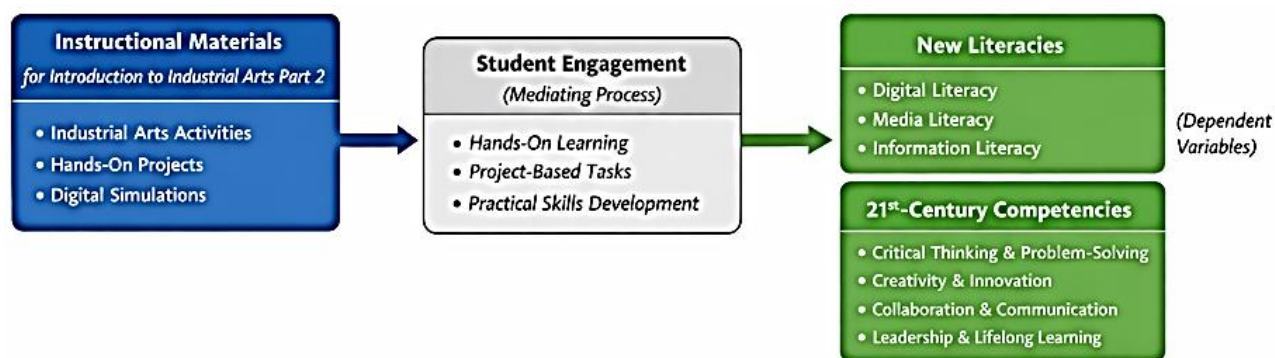


Figure 1: Conceptual Framework of Quasi-Experimental Study

Research Problem

The rapid advancement of digital technologies and the increasing demand for 21st-century competencies require that pre-service teachers possess more than foundational knowledge. They must also develop skills in digital, media, and information literacy, along with critical thinking, creativity, collaboration, and effective communication. Traditional teaching methods may not adequately prepare students to meet these demands.

Consequently, it is important to examine how integrating Technical-Vocational Education and Training (TVET) into teacher education, specifically through the use of instructional materials in *Introduction to Industrial Arts Part 2*, affects students' learning outcomes. Assessing the impact of this intervention on students' performance and development of 21st-century competencies can provide valuable insights for enhancing pre-service teacher preparation and ensuring readiness for modern classrooms.

Research Questions

This study aims to answer the following questions:

1. What are the pre-test and post-test mean scores of the control and experimental groups?
2. Is there a significant difference between the pre-test and post-test scores of the control group?

3. Is there a significant difference between the pre-test and post-test scores of the experimental group?

4. What are the post-test mean scores of the control and experimental groups in terms of:

- a. Critical Thinking
- b. Creativity
- c. Collaboration
- d. Communication

5. How do the post-test mean scores of the control and experimental groups compare in terms of:

- a. Critical Thinking
- b. Creativity
- c. Collaboration
- d. Communication

Research Design

This study employed a quasi-experimental pretest-posttest control group design to determine the effectiveness of TVET-based instructional materials in enhancing students' learning performance and 21st-century competencies. A quasi-experimental design is appropriate when intact groups are used and random assignment of participants is not feasible, allowing researchers to examine the effects of an educational intervention under real classroom conditions [15,16]. Two intact classes were assigned as the control and experimental

groups. Both groups completed a pre-test before the intervention and a post-test after the instructional period. The experimental group utilized the developed TVET-based instructional materials, whereas the control group received conventional lecture-discussion instruction. This design enabled the assessment of students' learning gains within each group and facilitated the descriptive comparison of post-test performance and competency outcomes between the two groups.

Participants

The participants consisted of 60 third-year Bachelor of Technology and Livelihood Education (BTLEd) students enrolled at the University of Science and Technology of Southern Philippines (USTP), Cagayan de Oro Campus. Students were enrolled in the course *Introduction to Industrial Arts Part 2* during the semester in which the study was conducted. Participants were assigned to either the experimental group ($n = 30$) or the control group ($n = 30$).

Although the study utilized two intact groups typical of educational settings, efforts were made to ensure comparability between groups through equivalent course enrollment, similar academic backgrounds, and administration of the same pretest before the intervention. Such procedures are recommended in quasi-experimental educational research to minimize selection bias and improve internal validity [15,16].

Validity and Reliability

The research instrument was subjected to content validation by three experts in teacher education and instructional materials development to ensure its relevance, clarity, appropriateness, and alignment with the intended learning outcomes. The validators' comments and recommendations were incorporated into the final version of the instrument before its administration. Reliability was established through a pilot test using Cronbach's alpha to determine the internal consistency of the instrument. According to Tavakol and Dennick, a Cronbach's alpha coefficient of 0.70 or higher indicates acceptable internal consistency for research instruments [17].

Data Analysis

Descriptive statistics, including mean, standard deviation, and mean gain scores, were used to summarize the participants' learning performance and 21st-century competency levels. A paired-samples *t*-test was employed to determine whether significant differences existed between the pre-test and post-test scores within the control group and within the experimental group. Descriptive comparisons of the post-test scores and competency mean scores of the two groups were likewise conducted to determine the extent of improvement following the instructional intervention. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), with the level of significance set at 0.05 [18,19].

RESULTS

Pre-test and Post-test Scores of Control and Experimental Group

Table 1 presents the pre-test and post-test scores of the control and experimental groups. Both groups demonstrated

improvements following the instructional intervention; however, the experimental group achieved a larger mean gain (17.8 points) than the control group (7.2 points). The paired-samples *t*-test indicated that the experimental group demonstrated a statistically significant improvement between the pre-test and post-test. Based on the descriptive comparison of post-test performance and mean gain scores, students who used the TVET-based instructional materials showed greater improvement than those who received conventional lecture-discussion instruction.

Table 1: Pre-test and Post-test Scores of Control and Experimental Group

Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Gain	t-value	p-value
Control	30	72.6 (6.3)	79.8 (5.7)	+7.2	2.03	0.071
Experimental	30	73.9 (5.8)	91.7 (6.4)	+17.8	6.27	<0.001

The higher post-test scores and greater mean gains obtained by the experimental group suggest that instructional materials grounded in TVET principles create meaningful learning experiences by integrating theoretical concepts with authentic practical activities. According to experiential learning theory, knowledge is developed through concrete experiences, reflective observation, abstract conceptualization, and active experimentation, enabling learners to construct deeper understanding through direct engagement with learning tasks [7]. Consequently, students who actively participated in hands-on activities and authentic problem-solving tasks were more likely to develop stronger conceptual understanding than those who learned primarily through lectures.

The findings of this study are consistent with previous research demonstrating the effectiveness of learner-centered instructional approaches. Problem-based learning has been shown to improve students' critical thinking and academic achievement by encouraging learners to analyze authentic situations and formulate appropriate solutions [6]. Similarly, experiential learning in technical and vocational education enhances students' employability skills and promotes meaningful learning by connecting classroom instruction with workplace applications [11]. These studies support the present findings, indicating that practice-oriented instructional strategies promote higher academic performance than conventional teacher-centered approaches.

Moreover, integrating digital technologies and interactive instructional strategies into teaching has been found to increase student engagement and facilitate deeper learning [5]. The instructional materials developed in the present study incorporated collaborative activities, practical exercises, and guided learning tasks that encouraged students to apply knowledge rather than merely memorize concepts. Such active engagement likely contributed to the higher posttest scores observed in the experimental group.

The present findings also support contemporary teacher education reforms that advocate competency-based and learner-centered instruction. Future teachers benefit not only from acquiring disciplinary knowledge but also from experiencing innovative instructional approaches that they can later implement in their own classrooms. Thus,

integrating TVET-based instructional materials may strengthen both pedagogical competence and professional readiness among pre-service teachers.

Post-test Scores of Control and Experimental Group in terms of Critical Thinking, Creativity, Collaboration, and Communication

Table 2 shows that the experimental group obtained consistently higher mean scores than the control group across all four dimensions of 21st-century competencies: critical thinking, creativity, collaboration, and communication. Among these competencies, collaboration exhibited the highest mean difference, followed by creativity, while critical thinking and communication likewise demonstrated substantial improvements. These findings indicate that the instructional materials enhanced not only academic achievement but also the essential competencies required for success in contemporary education and employment.

Table 2 Post-test Mean Comparison of Control and Experimental Group

Skills Dimension	Control Mean	Experimental Mean	Mean Difference	Remarks
Critical Thinking	3.9	4.6	+0.7	Higher Experimental Mean
Creativity	3.6	4.4	+0.8	Higher Experimental Mean
Collaboration	3.6	4.5	+0.9	Higher Experimental Mean
Communication	3.7	4.4	+0.7	Higher Experimental Mean

The findings support the widely accepted framework of 21st-century competencies, which identifies critical thinking, creativity, collaboration, and communication as fundamental skills required for lifelong learning and workforce readiness [3]. Through project-based activities, laboratory exercises, collaborative learning tasks, and authentic performance assessments, the instructional materials provided students with opportunities to practice these competencies in realistic educational contexts.

The results likewise align with recent international reports emphasizing that educational institutions should develop adaptable graduates capable of responding to rapid technological advancement, digital transformation, and evolving labor market demands [4,12]. TVET-based instruction provides an appropriate learning environment for cultivating these competencies because it combines theoretical knowledge with practical application while encouraging collaboration, innovation, and reflective learning.

The substantial improvement observed in collaboration may be attributed to the cooperative learning activities embedded within the instructional materials. Students were required to work in teams, exchange ideas, solve practical problems collectively, and reflect on shared learning experiences. Previous research has shown that collaborative learning environments promote active participation, interpersonal

communication, and teamwork, thereby strengthening students' social and professional competencies [11].

Similarly, the improvement in creativity suggests that students benefited from instructional activities requiring them to design solutions, generate alternative ideas, and apply technical knowledge to authentic workplace scenarios. Such experiences are consistent with constructivist learning principles, which emphasize active knowledge construction through exploration, inquiry, and experiential engagement [7]. The higher critical thinking scores obtained by the experimental group further indicate that the instructional materials encouraged learners to analyze problems, evaluate information critically, and make evidence-based decisions. Likewise, improvements in communication skills may be attributed to regular presentations, group discussions, peer feedback sessions, and collaborative project implementation, all of which required students to communicate ideas clearly and confidently throughout the learning process.

DISCUSSION

Overall, the findings suggest that TVET-based instructional materials provide a promising instructional approach for enhancing learning performance and 21st-century competencies among BTLED students. The results reinforce previous evidence supporting experiential learning, learner-centered pedagogy, and competency-based instruction in technical and vocational education [5,7].

More importantly, the present study extends the existing literature by providing quasi-experimental evidence on the effectiveness of TVET-based instructional materials specifically within Bachelor of Technology and Livelihood Education programs in the Philippine higher education context. While previous investigations have primarily focused on curriculum implementation, policy development, or employability outcomes, relatively few studies have examined the impact of structured instructional materials on both academic performance and 21st-century competency development among pre-service teachers. Therefore, this study contributes new empirical evidence supporting the integration of TVET-oriented instructional materials into teacher education curricula.

The findings have important implications for teacher educators, curriculum developers, and higher education institutions. Integrating TVET-based instructional materials into teacher education programs can better prepare future educators to implement authentic, learner-centered instructional practices aligned with competency-based education and workforce expectations. As educational systems continue to emphasize innovation, digital transformation, and lifelong learning, instructional approaches that combine theoretical knowledge with practical application are essential for preparing graduates who are competent, adaptable, and professionally responsive.

CONCLUSION

This study evaluated the effectiveness of TVET-based instructional materials in enhancing the learning performance and 21st-century competencies of Bachelor of Technology and Livelihood Education (BTLED) students enrolled in

Introduction to Industrial Arts Part 2. The findings demonstrated that although both the control and experimental groups improved from pretest to posttest, students who received instruction using the TVET-based instructional materials achieved greater gains in learning performance than those who received conventional lecture-discussion instruction. These results indicate that integrating structured, practice-oriented instructional materials into teacher education enhances students' understanding and application of course concepts.

The study further revealed that students who used the TVET-based instructional materials obtained higher mean scores in critical thinking, creativity, collaboration, and communication. These competencies were developed through experiential learning activities, collaborative projects, authentic problem-solving tasks, and practical applications that actively engaged students in the learning process. The findings support the growing body of evidence that learner-centered and competency-based instructional approaches are more effective than traditional teaching methods in preparing students for the demands of contemporary education and the workplace [3,5].

The study contributes to the literature by providing empirical evidence on the effectiveness of TVET-based instructional materials within Philippine teacher education. Unlike many previous investigations that focused primarily on curriculum implementation or employability outcomes, this study demonstrates that well-designed instructional materials can simultaneously improve academic achievement and foster essential 21st-century competencies among pre-service teachers. The findings therefore support the integration of TVET principles into teacher education curricula to prepare future educators capable of implementing innovative, learner-centered, and competency-based instructional practices.

Overall, the study concludes that TVET-based instructional materials represent an effective instructional innovation for strengthening both learning performance and 21st-century competencies among BTLED students. Their integration into teacher education programs has the potential to enhance instructional quality and produce graduates who are better prepared to respond to the evolving demands of schools, industry, and society.

Recommendations

Based on the findings of the study, the following recommendations are proposed.

1. For Teacher Educators. Teacher educators are encouraged to integrate TVET-based instructional materials into technical and professional education courses to promote active learning, collaboration, and the development of 21st-century competencies.
2. For Curriculum Developers. Curriculum planners should develop competency-based instructional materials that combine theoretical knowledge with authentic practical applications aligned with current industry standards and learning outcomes.
3. For Higher Education Institutions. Universities offering BTLED and other teacher education programs should provide institutional support for the

development, validation, and implementation of innovative instructional materials, including faculty training on learner-centered instructional strategies.

4. For Educational Policymakers and TVET Institutions. Educational agencies may consider promoting instructional innovations grounded in TVET principles as part of curriculum enhancement initiatives that strengthen graduate employability and workforce readiness.
5. For Future Researchers. Future studies are encouraged to replicate this investigation using larger and more diverse samples across multiple institutions, extend the duration of the instructional intervention, and examine additional outcomes such as digital literacy, self-directed learning, teaching self-efficacy, employability skills, and long-term retention of learning.

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