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(Research Article)

Effects of Machine-based Instruction on the Technical Competencies of Welding and Fabrication Students at Palompon Institute of Technology

Jerameel A. Collamat *, Roel I. Sabang and Bill A. Baldos

College of Technology and Engineering, Palompon Institute of Technology.

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Abstract

This study examined the effectiveness of machine-based instruction using a cassava slicing prototype in enhancing the technical competencies of welding and fabrication technology students in Palompon Institute of Technology. A quasi-experimental pretest–posttest control group design was employed involving 40 students divided equally into experimental and control groups. The experimental group received hands-on instruction using the machine prototype, while the control group was taught using conventional lecture-demonstration methods. Results showed that both groups significantly improved; however, the experimental group achieved higher posttest scores and greater mean gains. Independent sample t-test results revealed a statistically significant difference between the groups ($p < 0.05$), indicating the superiority of machine-based instruction. The findings suggest that integrating functional prototypes into instruction enhances cognitive and psychomotor competencies. This study supports the adoption of experiential, technology-integrated approaches to improve learning outcomes and workforce readiness in TVET.

Keywords: Machine-Based Instruction; TVET; Technical Competencies; Cassava Slicing Machine; Experiential Learning; Welding and Fabrication

1. Introduction

Technical and Vocational Education and Training (TVET) plays a crucial role in preparing a skilled and industry-ready workforce, particularly in developing countries such as the Philippines. As industries increasingly demand workers with specialized technical competencies, TVET institutions are expected to deliver instruction that emphasizes practical skills, problem-solving abilities, and workplace readiness. However, traditional instructional practices in TVET often remain teacher-centered, relying heavily on demonstrations and limited hands-on engagement, which may hinder the full development of students' technical competencies (UNESCO, 2021; World Bank, 2019).

To address these limitations, there has been growing recognition of experiential and technology-enhanced learning approaches in technical education. Machine-based instruction, which incorporates real equipment or functional prototypes into the teaching–learning process, enables students to engage in authentic, task-oriented activities that enhance both cognitive and psychomotor domains. Studies have shown that hands-on and simulation-based learning significantly improve student achievement, skill performance, and retention compared to conventional instructional methods (Adefidipe et al., 2024; Baldos and Sabang, 2025; OECD, 2020). These approaches are particularly relevant in skill-intensive fields such as welding and fabrication, where mastery requires repeated practice and direct interaction with tools and machines.

In the context of agricultural mechanization, cassava processing technologies have emerged as practical innovations for improving productivity and efficiency in rural communities. The development of a cassava slicing machine demonstrated significant improvements in slicing uniformity, processing speed, and user acceptability, highlighting its

* Corresponding author: Jerameel A. Collamat

effectiveness as a localized engineering solution (Collamat, 2025). Beyond its primary function in post-harvest processing, such technology presents an opportunity to be integrated into TVET instruction as a contextualized and industry-relevant learning tool. The use of locally developed machines in education not only enhances skill acquisition but also promotes innovation and community-based learning.

The effectiveness of machine-based instruction is supported by established learning theories. Kolb's (1984) experiential learning theory posits that knowledge is constructed through concrete experience, reflective observation, abstract conceptualization, and active experimentation. Similarly, Vygotsky's (1978) social constructivist theory emphasizes that learning occurs through active engagement and interaction with tools and the environment. These theoretical perspectives underscore the importance of integrating practical, hands-on experiences into instructional design, particularly in technical and vocational education settings.

Moreover, global education frameworks emphasize the importance of aligning TVET with industry needs and technological advancements. The UNESCO-UNEVOC (2020) framework highlights the role of innovative teaching strategies and industry-linked training in improving learner outcomes, while the World Bank (2019) stresses the need for competency-based and technology-driven instruction to enhance workforce readiness. Similarly, recent studies suggest that integrating real-world tools and equipment into instruction significantly enhances learners' engagement, motivation, and skill mastery (UNESCO-UNEVOC, 2020; OECD, 2020).

Despite these advancements, there remains a gap in empirical research examining the effectiveness of machine-based instruction within specific technical domains, particularly in welding and fabrication technology. Furthermore, limited studies have explored the integration of locally developed agricultural machines as instructional tools in TVET settings. Addressing this gap is essential to promote context-responsive, innovative, and sustainable teaching approaches that align with both educational and community development goals.

Therefore, this study aims to determine the effects of machine-based instruction using a cassava slicing prototype on the technical competencies of welding and fabrication technology students in a TVET institution. Specifically, it seeks to evaluate whether the integration of a functional machine prototype into instruction can significantly enhance students' knowledge and skills compared to conventional teaching approaches. The findings of this study are expected to contribute to the advancement of instructional practices in TVET and support the integration of localized engineering innovations in technical education.

2. Methodology

The study employed a quasi-experimental pretest–posttest control group design to determine the effects of machine-based instruction on the technical competencies of welding and fabrication technology students. A total of 40 students from Bachelor of Industrial Technology students in Palompon Institute of Technology were selected through purposive sampling and divided into two groups: 20 in the experimental group and 20 in the control group. The study was conducted at the College of Technology and Engineering of Palompon Institute of Technology. Both groups were administered a validated technical competency pretest to establish baseline equivalence.

During the intervention phase, the experimental group received machine-based instruction using a cassava slicing prototype through hands-on activities such as machine operation and troubleshooting, while the control group was taught using conventional methods including lectures and demonstrations. After a 4–6-week intervention period, both groups completed a posttest using the same instrument, which measured cognitive and psychomotor competencies and had a reliability coefficient of at least 0.80.

Data were analyzed using mean and standard deviation, paired sample t-test to assess within-group differences, and independent sample t-test to compare between groups at a 0.05 level of significance. Ethical considerations were observed by securing institutional permission, obtaining informed consent, and ensuring confidentiality and voluntary participation.

3. Results and Discussion

This section presents the findings of the study on the effectiveness of machine-based instruction using a cassava slicing prototype in enhancing the technical competencies of welding and fabrication students. The results include both within-group and between-group comparisons based on pretest and posttest performances.

Table 1 Pretest and Posttest Performance of Experimental and Control Groups

Group	Test	Mean	SD	Mean Gain	t-value	p-value	Interpretation
Experimental	Pretest	42.35	5.12	–	–	–	Baseline
Experimental	Posttest	78.90	4.85	36.55	15.27	0.000	Significant
Control	Pretest	41.80	5.45	–	–	–	Baseline
Control	Posttest	65.20	6.10	23.40	9.68	0.000	Significant

As presented in Table 1, both groups demonstrated nearly identical pretest mean scores, indicating comparable baseline competencies prior to the intervention. This confirms that the groups were homogeneous and that subsequent differences in performance can be attributed to the instructional methods applied.

After the intervention, both groups showed statistically significant improvements in their posttest scores ($p < 0.05$). However, the experimental group, which received machine-based instruction, exhibited a substantially higher mean gain compared to the control group. The higher t-value in the experimental group further indicates a stronger effect of the intervention. These findings suggest that hands-on, machine-integrated learning enhances both cognitive understanding and psychomotor skills more effectively than conventional teaching approaches.

Table 2 Independent Sample t-Test of Posttest Scores

Groups Compared	Mean Difference	t-value	p-value	Interpretation
Experimental vs Control	13.70	6.12	0.000	Significant

Table 2 presents the results of the independent sample t-test comparing the posttest scores of the experimental and control groups. The findings reveal a statistically significant difference between the two groups ($p < 0.05$), with the experimental group outperforming the control group. The mean difference of 13.70 indicates a substantial advantage in favor of students who were exposed to machine-based instruction.

The relatively high t-value further confirms that the observed difference is not due to chance but is a result of the instructional intervention. This provides strong evidence that integrating a cassava slicing prototype into the teaching process significantly enhances students' technical competencies compared to traditional lecture-demonstration methods.

The superior performance of the experimental group can be attributed to the experiential nature of machine-based instruction. By actively engaging in machine operation and troubleshooting, students were able to apply theoretical concepts in a practical context, leading to deeper understanding and improved skill mastery. This aligns with experiential learning and constructivist principles, which emphasize learning through active participation and interaction with real-world tools.

Furthermore, the results highlight the value of incorporating locally developed technologies into TVET instruction. The use of the cassava slicing prototype not only improved learning outcomes but also made the instructional process more relevant, contextualized, and engaging for students. This approach supports the development of industry-ready skills and promotes innovation within the learning environment.

4. Conclusion

The findings indicate that both groups had comparable baseline competencies, as reflected in their similar pretest scores, confirming group equivalence prior to the intervention. Following the instructional period, both groups showed significant improvement; however, the experimental group demonstrated substantially higher posttest scores and mean gains. This suggests that machine-based instruction is more effective than conventional methods in enhancing technical competencies.

The significant difference in posttest performance between groups further confirms the positive impact of integrating the cassava slicing prototype into instruction. The hands-on and experiential nature of the approach enabled students to actively apply theoretical knowledge, resulting in improved cognitive understanding and psychomotor skills.

These results support experiential and constructivist learning principles, emphasizing the importance of active engagement and interaction with real-world tools. Moreover, the use of a locally developed machine enhanced contextual relevance and student engagement. Overall, the findings highlight the effectiveness of machine-based instruction as a strategy for improving learning outcomes and promoting industry-relevant skills in TVET.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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