# Tech-Infused Learning: ICT-Enhanced Problem-Based Learning for Critical Thinking Skills Improvement

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## ABSTRACT

This study evaluated the effectiveness of Information and Communication Technology (ICT)-enhanced Problem-Based Learning (PBL) in improving the critical thinking skills of Grade 12 Technical-Vocational-Livelihood (TVL)–Home Economics students at Perez National High School. It provided practical training in workplace safety practices through immersive simulations designed to bridge the gap between theoretical knowledge and real-world applications. Specifically, the study addressed students' limited understanding of workplace safety practices to help mitigate the risks associated with unsafe workplace behaviors.

The study employed a quasi-experimental research design and used criterion sampling, a purposive sampling technique, to select 40 students who were divided into two groups: 20 students in the control group, who received traditional instruction, and 20 students in the experimental group, who were taught using ICT-enhanced PBL. A 30-item multiple-choice test was administered to assess students' critical thinking skills before and after the intervention. The data were analyzed using the arithmetic mean and independent-samples t-tests.

The pretest results indicated that the control group performed within the below-average range, while the experimental group performed within the average range. Posttest results showed improvements in both groups, with the experimental group achieving above-average scores. Statistical analysis further revealed that ICT-enhanced PBL significantly improved students' critical thinking skills compared with traditional instructional methods.

The findings highlight the transformative role of ICT in vocational education, particularly its potential to promote critical thinking, active learning, and contextualized workplace safety training. The study recommends integrating ICT-enhanced PBL into TVL programs, equipping educators with the necessary ICT-based instructional competencies, and increasing investments in ICT infrastructure. Overall, this approach promotes a holistic set of competencies that combines technical proficiency with analytical thinking, thereby preparing vocational education for a dynamic and future-oriented transformation.

**Keywords:** ICT-enhanced, Problem-based learning, critical thinking skills, 21st Century Education

## CONTEXT AND RATIONALE

Critical thinking is an essential component of modern education that must be continuously developed and strengthened, particularly in the context of the Fourth Industrial Revolution (4IR) (Wilson & Narasuman, 2020; Boleng et al., 2017; Hidayati et al., 2020), where information is abundant and technological changes occur rapidly and radically.

Many Technical-Vocational-Livelihood (TVL) Cookery students may have limited hands-on experience in actual kitchen environments, making it challenging for them to recognize, assess, and manage workplace hazards effectively. Consequently, students may lack a comprehensive understanding of essential workplace safety practices, potentially leading to unsafe behaviors in professional kitchen settings. This situation highlights the need to explore effective instructional approaches that provide students with practical training in performing workplace safety procedures. In this regard, immersive and interactive simulations may help bridge the gap between theoretical knowledge and real-world applications.

Furthermore, in actual workplace environments, students are often confronted with unpredictable situations that require immediate and practical solutions. Traditional instructional methods may not fully prepare students to respond effectively to these challenges. ICT-enhanced Problem-Based Learning (PBL) provides opportunities for students to engage in simulated workplace scenarios that replicate actual kitchen environments and potential hazards. Through these simulations, students can develop problem-solving and critical thinking skills by addressing realistic situations, such as proper food handling, the safe operation of kitchen equipment, and appropriate responses to workplace emergencies. The integration of technology provides dynamic and interactive learning experiences that promote a deeper understanding of workplace safety concepts and procedures.

ICT-enhanced PBL has the potential to promote active engagement, problem-solving, and critical thinking by immersing students in simulated real-world situations that require analytical reasoning and informed decision-making. Previous studies indicate that integrating ICT tools into PBL encourages students to explore, question, analyze, and develop solutions to complex problems, thereby enhancing their critical thinking skills (Zhu & Baylen, 2005). These competencies are particularly important in kitchen environments, where quick thinking, sound judgment, and effective problem-solving are essential for maintaining safety and operational efficiency.

Thus, investigating the effectiveness of ICT-enhanced PBL in improving the critical thinking skills of TVL–Home Economics Cookery students in performing workplace safety practices is significant. The findings of this study may provide valuable insights for developing instructional strategies, informing educational policies, and strengthening practical interventions in vocational education. Furthermore, the results may serve as a basis for action planning and policy enhancement to improve the delivery of technology-integrated instruction in TVL programs. The study seeks to establish how integrating ICT with problem-based learning can enhance students' critical thinking skills and prepare them to address real-world workplace challenges. Through technology-supported learning experiences, students can strengthen both their analytical abilities and digital literacy while developing the capacity to identify, assess, and respond appropriately to potential safety hazards.

Overall, utilizing the findings of this study to inform educational policies and instructional practices may help ensure that TVL–Home Economics Cookery students are better prepared to meet the demands of actual workplace environments. By integrating ICT-enhanced PBL into vocational instruction, educational institutions can promote the development of technical competencies, critical thinking, and informed decision-making, particularly in maintaining workplace safety.

**Innovation, Intervention, or Strategy**

The innovation of ICT-enhanced Problem-Based Learning (PBL) was strategically designed to address the key challenges faced by Technical-Vocational-Livelihood (TVL)–Home Economics Cookery students, particularly in developing the critical thinking skills necessary for performing workplace safety practices.

Problem-Based Learning involves presenting students with real-world challenges that require critical thinking and problem-solving. This approach is particularly suitable for safety and culinary training, where practical application, sound judgment, and hands-on problem-solving are essential.

Furthermore, integrating Information and Communication Technology (ICT) tools into this instructional approach transformed the learning experience by allowing students to engage in realistic, interactive, and

technology-supported simulations that reflect actual workplace environments. The ICT-enhanced PBL approach encouraged students to work through structured safety-related problems by analyzing situations, formulating hypotheses, and exploring possible solutions.

Moreover, this approach required students to think critically about their decisions and understand their potential consequences, thereby fostering the development of critical thinking skills essential for maintaining workplace safety. Another key component of ICT-enhanced PBL was the integration of collaborative learning activities. Students worked in pairs or groups to address problem scenarios, discuss their reasoning, evaluate one another's decisions, and collaboratively develop safer and more effective solutions. This collaborative learning environment simulated real-world teamwork in professional kitchen settings while reinforcing workplace safety practices and critical thinking skills.

The strategic integration of ICT into PBL was intended to strengthen students' critical thinking skills by providing opportunities to engage directly with workplace safety problems through interactive technological resources. Through these learning experiences, students developed a deeper understanding of safety protocols and strengthened their ability to anticipate, identify, and manage potential workplace hazards.

**Implementation of the ICT-Enhanced PBL Strategy**

ICT-enhanced Problem-Based Learning was integrated into the Cookery lesson on Perform Workplace and Safety Practices. The researchers followed a systematic, step-by-step approach to incorporate ICT tools into the teaching and learning process.

**Step 1**: Identification of Learning Objectives.

The researchers established specific learning objectives by identifying the essential workplace safety competencies that students needed to acquire. These objectives ensured that students understood fundamental safety practices and clarified how ICT tools, such as video tutorials, interactive simulations, and digital assessments, could support and enhance their learning experiences.

**Step 2**: Development of Real-World Problem Scenarios.

Realistic workplace safety scenarios were designed to present students with situations commonly encountered in kitchen environments. These scenarios encouraged collaboration, critical thinking, communication, and problem-solving while allowing students to recognize and analyze potential workplace hazards.

**Step 3**: Selection of Appropriate ICT Tools.

ICT resources were carefully selected to complement the identified learning objectives and problem scenarios. These included online learning resources, virtual simulations for hazard identification, and instructional videos demonstrating proper workplace safety procedures.

**Step 4**: Presentation of the Problem Scenario.

The researchers introduced the problem scenarios to the students and provided clear instructions for developing appropriate solutions. Students were encouraged to investigate relevant safety practices, utilize available ICT resources, and apply their knowledge to address the identified problems. Specific roles and tasks were assigned to guide their participation and ensure active engagement in the learning activities.

**Step 5**: Exploration and Collaborative Problem-Solving.

Students explored the selected ICT tools, gathered relevant information, and participated in collaborative discussions. They analyzed the presented situations, evaluated possible solutions, and applied their findings to resolve the workplace safety problems. This stage emphasized analytical reasoning, decision-making, and teamwork.

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**Step 6**: Development and Presentation of Solutions.

After analyzing the problem scenarios, students developed and presented their proposed solutions using digital presentation platforms such as Microsoft PowerPoint, Canva, and Google Slides. These platforms enabled students to organize their ideas, communicate their findings, and demonstrate their understanding of appropriate workplace safety practices.

**Step 7**: Evaluation, Feedback, and Reflection.

Students presented their proposed workplace safety solutions and received constructive feedback from their peers and the researcher. They also engaged in self-reflection to evaluate their decision-making processes and identify how ICT tools contributed to their learning. This stage provided opportunities to assess their understanding, reasoning, and ability to recommend appropriate safety measures.

**Step 8**: Assessment and Reinforcement of Learning.

Various assessment activities, including quizzes and written essays, were administered to reinforce the learning objectives and evaluate students' understanding of workplace safety practices. Feedback was provided to help students improve their proposed safety solutions, address misconceptions, and deepen their understanding of the concepts and procedures discussed.

Overall, this structured instructional strategy integrated ICT-enhanced Problem-Based Learning into Cookery instruction to provide students with realistic, interactive, and collaborative learning experiences. Through simulated workplace safety scenarios and technology-supported problem-solving activities, students were given opportunities to strengthen their critical thinking skills and develop the competencies necessary to recognize hazards, make informed decisions, and maintain a safe working environment.

**Action Research Questions**

This study aimed to determine the effectiveness of ICT-enhanced Problem-Based Learning (PBL) in improving the critical thinking skills of Grade 12 Technical-Vocational-Livelihood (TVL)–Home Economics students at Perez National High School during the School Year 2024–2025.

Specifically, this study sought to answer the following questions:

- What is the level of critical thinking skills of the control and experimental groups before the implementation of ICT-Enhanced Problem-Based Learning?
- What is the level of critical thinking skills of the control and experimental groups after the implementation of ICT-Enhanced Problem-Based Learning?
- Is there a significant difference in the critical thinking skills of the control and experimental groups before and after the implementation of ICT-Enhanced Problem-Based Learning?

**Hypothesis**

There is no statistically significant difference in the critical thinking skills of the control and experimental groups before and after the implementation of ICT-enhanced Problem-Based Learning (PBL).

**Action Research Methods**

**Participants and/or other Sources of Data and Information**

The participants in this study were 40 Grade 12 Technical-Vocational-Livelihood (TVL)–Home Economics students enrolled at Perez National High School during the School Year 2024–2025. The participants were divided equally into two groups: the experimental group and the control group, with 20 students in each group. The grouping was based on the students' first-quarter grades in Cookery. Students with similar grades were

paired to ensure comparable academic performance between the two groups. The experimental group received instruction through the integration of ICT-enhanced Problem-Based Learning (PBL) in the Cookery lesson on Perform Workplace and Safety Practices, while the control group received instruction using the traditional teaching approach.

The student-participants had a foundation in practical skills related to food preparation, cooking techniques, and kitchen management. They were familiar with various cooking tools and equipment, as well as food handling and sanitation practices. These foundational competencies provided relevant background knowledge for applying workplace safety practices in a kitchen environment.

This study employed criterion sampling, a specific form of purposive sampling, to select participants who met predetermined inclusion criteria. According to Patton (2002), criterion sampling involves selecting information-rich cases that meet specific criteria relevant to the purpose of the study. This sampling approach ensures that the selected participants possess characteristics directly related to the research objectives, thereby supporting the collection of relevant and meaningful data.

The selection of student-participants was based on specific inclusion criteria established by the researchers in accordance with the research questions and objectives. These criteria included the following: (1) students must be enrolled in Grade 12 under the Technical-Vocational-Livelihood (TVL) Track, specifically the Home Economics strand; (2) students must have access to electronic devices or gadgets; (3) students must have an internet connection; and (4) students must voluntarily agree to participate in the study and be willing to devote time to the research activities.

By establishing these criteria, the researchers ensured that the selected participants were directly relevant to the study and had access to the technological resources necessary to participate in the ICT-enhanced PBL intervention.

**Data Gathering Methods**

To conduct this study, the researchers prepared a formal communication letter requesting permission from the School Principal of Perez National High School to undertake the research. Upon approval of the request, the researcher coordinated with the Grade 12 Cookery subject teacher and presented another letter requesting access to the first-quarter grades of Grade 12 TVL–Home Economics (Cookery) students. These grades served as the basis for selecting and grouping the participants in the study.

Furthermore, the researchers assured the participants of the privacy and confidentiality of their identities and the information they provided throughout the research process. Upon securing the necessary approvals and addressing the ethical considerations of the study, the researchers proceeded with the implementation of the data-gathering procedures.

The 40 student-participants, consisting of 20 students in the control group and 20 students in the experimental group, were administered a pretest to determine their initial levels of critical thinking skills. Following the administration of the pretest, the researcher conducted instructional sessions for both groups. The control group received instruction through the traditional teaching approach, while the experimental group was taught using ICT-enhanced Problem-Based Learning (PBL). A lesson plan served as the instructional guide for both groups. The lesson focused on the Cookery competency, Perform Workplace and Safety Practices. The lesson plans were validated by the Senior High School TVL Master Teacher to ensure their appropriateness and alignment with the intended learning objectives.

The instructional intervention was implemented over five days, depending on the availability of the student-participants and the teacher-researcher. This period included the administration of the pretest, the implementation of the respective teaching approaches, and the administration of the posttest. After completing the instructional sessions, the same 30-item test was administered as a posttest to both groups to determine changes in students' critical thinking skills following the intervention.

The use of a quasi-experimental design involving pretest and posttest assessments is consistent with the approach discussed by Zhan and Zhang (2023). Such a research design is particularly useful in evaluating educational interventions, including ICT-enhanced PBL, by examining changes in students' performance before and after the implementation of an instructional strategy.

A researcher-made, 30-item multiple-choice test served as the primary research instrument for collecting data from the control and experimental groups. The instrument was administered as both a pretest and a posttest to determine the participants' levels of critical thinking skills before and after the intervention. The test covered the Cookery competency, Perform Workplace and Safety Practices, and consisted of four answer options for each item. The interpretation of the test scores was based on the following performance categories, adapted from Guardian et al. (2012):

| **Score Range** | **Interpretation** |
|---|---|
| 24.1–30 | Outstanding |
| 18.1–24 | Above Average |
| 12.1–18 | Average |
| 6.1–12 | Below Average |
| 0–6 | Poor |

In developing the research instrument, the researchers sought advice and consulted Senior High School TVL teachers regarding the construction and appropriateness of the test items. The instrument underwent three essential processes: content validation, reliability testing, and pilot testing or a dry run.

Content validation was conducted by experts and practitioners in TVL–Home Economics, particularly in Cookery. They evaluated the test items in terms of content relevance, clarity, coherence, and alignment with the objectives of the study. Their feedback and recommendations were considered in refining the instrument to ensure that it adequately measured the intended competencies.

Following the validation process, the researchers conducted a pilot test or dry run involving 15 Grade 12 TVL students who were not included in the actual study. These students answered the researcher-made 30-item multiple-choice test. The pilot testing was conducted to determine the clarity, appropriateness, and comprehensibility of the test items and to identify possible revisions before the actual administration of the instrument.

To establish the reliability of the research instrument, the researchers employed the split-half reliability method. This procedure assessed the internal consistency of the test by dividing the items into two halves and comparing the scores obtained from each half. The results were used to determine the consistency of the instrument in measuring the intended competencies.

The researchers also conducted item analysis and test evaluation to examine students' responses to individual test items. This process helped assess the quality, difficulty, and discriminatory power of the questions and identify items that required revision or improvement.

Furthermore, the study by Zainuddin and Halili (2016), which examined ICT-enhanced Problem-Based Learning and its implementation in educational settings, highlighted the importance of validating instructional frameworks and conducting pilot testing before full implementation. Such processes help establish the appropriateness of instructional strategies and assessment procedures while supporting the effective integration of ICT into teaching and learning.

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**Data Analysis**

This study employed a quasi-experimental research design to determine the effectiveness of ICT-enhanced Problem-Based Learning (PBL) in improving the critical thinking skills of Grade 12 Technical-Vocational-Livelihood (TVL)–Home Economics–Cookery students. The design involved pretest and posttest measurements to evaluate changes in students' critical thinking skills and provide a clearer understanding of the effectiveness of the intervention.

According to Wang and Hannafin (2020), the use of pretest and posttest assessments in quasi-experimental research provides a means of evaluating the effects of instructional interventions. Such an approach supports the assessment of changes in students' performance and understanding following the implementation of technology-enhanced collaborative learning strategies.

Furthermore, the researchers employed appropriate statistical tools to analyze and interpret the data gathered. To determine the average level of students' critical thinking skills based on their pretest and posttest scores, the arithmetic mean and mean percentage score (MPS) were used, following the respective formulas presented below:

**Simple Mean (Arithmetic Mean).** The formula was shown below.

$$\text{Mean} = \frac{\Sigma x}{N}$$

Where:

M = mean of the pupils' score

∑x =sum of pupils' score

N =total number of pupils

However, the independent-samples t-test was used to determine whether there was a statistically significant difference in the critical thinking skills of the control and experimental groups before and after the implementation of ICT-enhanced Problem-Based Learning (PBL).

**Independent-Samples t-Test**

The formula used to calculate the independent-samples t-test is presented below:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

- $\bar{X}_1$ = Mean of group 1
- $\bar{X}_2$ = Mean of group 2
- $s_1^2$ = Variance of group 1
- $s_2^2$ = Variance of group 2
- $n_1$ = Sample size of group 1
- $n_2$ = Sample size of group 2

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# DISCUSSION OF RESULTS AND REFLECTION

**Table 1. Level of Critical Thinking Skills of Control and Experimental Groups before the Implementation of ICT-Enhanced Problem-Based Learning**

| Levels | Control Group | | Experimental Group | |
|---|---|---|---|---|
| | **Frequency** | **Percentage** | **Frequency** | **Percentage** |
| Above Average | | | 1 | 5 |
| Average | 7 | 35 | 8 | 40 |
| Below Average | 13 | 65 | 11 | 55 |
| Total | 20 | 100 | 20 | 100 |
| **Sum of Scores** | **224** | | **259** | |
| **Mean** | **11.2** | | **12.95** | |
| **Interpretation** | **Below Average** | | **Average** | |

Table 1 presents the level of critical thinking skills of the control and experimental groups before the implementation of ICT-Enhanced Problem-Based Learning. The data revealed that the level of critical thinking skills of the control group was below average, whereas that of the experimental group was average. In the control group, seven (7) students, or 35%, were classified as having average critical thinking skills, while thirteen (13) students, or 65%, were classified as below average. These findings, based on the pre-test results, indicate that the majority of students in the control group had below-average critical thinking skills. The total score was 224, with an overall mean score of 11.20, which was classified as below average.

Meanwhile, in the experimental group, one (1) student, or 5%, was classified as above average, eight (8) students, or 40%, were classified as average, and eleven (11) students, or 55%, were classified as below average. These findings, based on the pre-test results, indicate that the majority of students in the experimental group also had below-average critical thinking skills. The total score was 259, with an overall mean score of 12.95, which was classified as average.

**Table 2. Level of Critical Thinking Skills of Control and Experimental Groups after the Implementation of ICT-Enhanced Problem-Based Learning**

| Levels | Control Group | | Experimental Group | |
|---|---|---|---|---|
| | **Frequency** | **Percentage** | **Frequency** | **Percentage** |
| Outstanding | | | 6 | 30 |
| Above Average | 9 | 45 | 10 | 50 |
| Average | 9 | 45 | 4 | 20 |
| Below Average | 2 | 10 | | |
| Total | 20 | 100 | 20 | 100 |

| | | |
|---|---|---|
| **Sum of Scores** | **354** | **398** |
| **Mean** | **17.7** | **21.4** |
| **Interpretation** | **Average** | **Above Average** |

The data revealed that the level of critical thinking skills of the control group was average, whereas that of the experimental group was above average.

In the control group, nine (9) students, or 45%, were classified as having above-average critical thinking skills, another nine (9) students, or 45%, were classified as average, and two (2) students, or 10%, were classified as below average. These findings, based on the post-test results, indicate that the students in the control group were equally distributed between the above-average and average categories, with only a small proportion classified as below average. The total score was 354, with an overall mean score of 17.70, which was classified as average.

Meanwhile, in the experimental group, six (6) students, or 30%, were classified as outstanding, ten (10) students, or 50%, were classified as above average, and four (4) students, or 20%, were classified as average. These findings, based on the post-test results, indicate that the majority of students in the experimental group demonstrated above-average critical thinking skills. The total score was 428, with an overall mean score of 21.40, which was classified as above average.

**Table 3. Significant Difference in the Level of Critical Thinking Skills of Control Group and Experimental Group before and after the Implementation of ICT-Enhanced Problem-Based Learning**

| Variable | df | Mean (Control) | Mean (Experimental) | Computed t-value | Critical t-value (0.05, 2-tailed) | Decision | Impression (0.05 Level) |
|---|---|---|---|---|---|---|---|
| Pre-test | 36.9 | 11.2 | 12.3 | -1.03 | ±2.026 | Fail to Reject Ho | No significant difference |
| Post-test | 36.7 | 17.7 | 21.3 | -3.236 | ±2.027 | Reject Ho | Significant difference |

The results revealed that the comparison of critical thinking test scores between the control and experimental groups prior to the implementation of the ICT-Enhanced Problem-Based Learning (ICT-PB) intervention showed no statistically significant difference. The control group ($M = 11.20$, $SD = 3.07$) and the experimental group ($M = 12.30$, $SD = 3.66$) yielded a Welch's t-test result of $t(\approx 36.90) = -1.030$, $p = 0.3097$. The 95% confidence interval for the mean difference ranged from −1.064 to 3.264. Cohen's d for the pretest difference was 0.326, indicating a small effect size. These findings suggest that the two groups had comparable levels of critical thinking skills before the implementation of the intervention.

However, following the implementation of ICT-Enhanced Problem-Based Learning, the experimental group demonstrated substantially higher post-test scores than the control group. The experimental group ($M = 21.30$, $SD = 3.84$) outperformed the control group ($M = 17.70$, $SD = 3.16$). The difference was statistically significant, as indicated by Welch's t-test, $t(\approx 36.66) = -3.236$, $p = 0.0026$, with a 95% confidence interval for the mean difference ranging from 1.345 to 5.855. Cohen's $d = 1.023$, indicating a large effect size. These results suggest

that the ICT-PB intervention was associated with a meaningful improvement in students' critical thinking skills compared with the control condition.

Furthermore, the non-significant pretest result suggests that there was no statistically significant difference between the two groups' critical thinking skills before the intervention. This provides support for the comparability of the groups at baseline, although a non-significant result alone does not establish baseline equivalence. Meanwhile, the significant post-test difference ($p = 0.0026$), together with the large effect size ($d \approx 1.02$), provides strong evidence of a substantial positive difference in the critical thinking performance of students exposed to ICT-Enhanced Problem-Based Learning. Moreover, the fact that the 95% confidence interval for the post-test mean difference does not include zero reinforces the statistical significance of the observed difference, which was approximately 3.60 points on the test scale.

The findings of this study on ICT-Enhanced Problem-Based Learning (PBL) and its effectiveness in improving the critical thinking skills of Technical-Vocational-Livelihood (TVL) Cookery students in performing workplace safety practices underscore the transformative potential of integrating technology into vocational education.

In terms of the theoretical implications, the findings support constructivist learning theories, which posit those students learn best when they are actively engaged in meaningful and context-rich learning experiences. ICT-Enhanced PBL also aligns with Vygotsky's concept of the Zone of Proximal Development (ZPD), wherein technology serves as a scaffolding tool that helps bridge the gap between what students can accomplish independently and what they can achieve with appropriate guidance and support.

Nirbita, Joyoatmojo, and Sudiyanto (2018) found that "ICT media assisted problem-based learning was able to improve students' critical thinking ability, especially in questioning, argumentation, information gathering, problem analysis, and decision-making" (p. 301). This finding supports the present study's results, which showed that the experimental group exposed to ICT-Enhanced Problem-Based Learning significantly outperformed the control group in terms of critical thinking skills.

Similarly, Wardani and Fiorintina (2023) reported that "there is a significant effect of the problem-based learning model on students' critical thinking skills, as indicated by the post-test results of the experimental group being higher than the control group" (p. 354). This finding is consistent with the present study, in which the experimental group demonstrated significantly higher post-test performance than the control group.

The study highlights several key insights. First, critical thinking is an essential competency in vocational education, particularly in fields such as cookery, where students must adapt to real-world challenges, including adhering to workplace safety standards, solving unexpected problems, and ensuring efficiency in the workplace. Second, the findings demonstrate that integrating ICT tools with problem-based learning scenarios can promote deeper student engagement and provide opportunities for learners to analyze, evaluate, and apply their knowledge effectively.

In conclusion, this study highlights the potential of combining technology with Problem-Based Learning as an effective instructional strategy for developing critical thinking skills among TVL students, particularly in cookery, where precision, adaptability, and workplace safety are essential. This pedagogical approach offers opportunities to transform vocational education into a more dynamic, effective, and future-ready learning environment.

## CONCLUSIONS

Based on the findings of the study, the following conclusions were drawn:

- The pretest results revealed no statistically significant difference in the critical thinking skills of the control and experimental groups, suggesting that both groups had comparable levels of performance before the intervention.

- The post-test results showed a statistically significant difference in favor of the experimental group exposed to ICT-Enhanced Problem-Based Learning (ICT-PBL), indicating that the intervention was associated with improved critical thinking performance among students.

- The large effect size (Cohen's d ≈ 1.02) demonstrated that the observed difference between the two groups was substantial, suggesting meaningful educational implications for the use of ICT-PBL in developing students' critical thinking skills.

- The findings support the integration of information and communication technology into problem-based learning as a promising instructional approach for developing higher-order thinking skills, particularly analysis, evaluation, problem-solving, and decision-making in TVL–Cookery education.

**Recommendations**

In light of the findings and conclusions, the following recommendations are proposed:

- **For Teachers:** Teachers are encouraged to integrate ICT-Enhanced Problem-Based Learning into their instructional practices through contextualized workplace scenarios, interactive activities, and problem-solving tasks that promote critical thinking and decision-making.

- **For School Administrators:** Schools should provide adequate ICT infrastructure, technological resources, instructional materials, and professional development opportunities to support the effective implementation of ICT-PBL.

- **For Students:** Students should actively participate in technology-supported problem-solving activities and practical workplace safety exercises to strengthen their analytical, evaluative, and decision-making skills.

- **For Curriculum Developers:** ICT-enhanced problem-based learning activities should be incorporated into relevant Technical-Vocational-Livelihood competencies, particularly in occupational health and safety, hazard identification, and workplace risk prevention.

- **For Future Researchers:** Similar studies should be conducted using larger and more diverse samples across different grade levels, TVL specializations, and subject areas to determine the applicability of the findings in other educational contexts.

- **For Future Research Methodologies:** Researchers are encouraged to incorporate qualitative approaches, such as interviews, classroom observations, and student reflections, together with performance-based assessments and practical demonstrations to obtain a more comprehensive understanding of students' critical thinking development.

- **For Longitudinal Research:** Follow-up assessments and longitudinal studies are recommended to determine whether improvements in students' critical thinking skills are sustained over time following continuous exposure to ICT-PBL.

**Action Plan**

In the study entitled Tech-Infused Learning: ICT-Enhanced Problem-Based Learning for Critical Thinking Skills Improvement of TVL Home Economics Cookery Students, the researchers aim to disseminate and utilize the findings to promote educational innovation and develop appropriate interventions. The findings may be applied in several ways, including the following:

- Policy Development: The findings could provide empirical evidence supporting the integration of ICT-enhanced problem-based learning (PBL) into the curriculum. They may also serve as a basis for

developing or improving policies that emphasize critical thinking skills in Technical-Vocational-Livelihood (TVL) education.

- Curriculum Design: The results of the study could guide curriculum developers in incorporating ICT and PBL approaches into instructional programs, ensuring that learning activities are aligned with the development of students' critical thinking skills.
- Teacher Training Programs: The research findings could serve as a basis for designing professional development programs and workshops that equip teachers with the knowledge and skills necessary to implement ICT-enhanced PBL effectively.
- Improvement of Instructional Practices: By disseminating the research findings through conferences, academic publications, and school-based Learning Action Cell (LAC) sessions, the researchers could encourage educators to adopt innovative instructional strategies in teaching Cookery and other related TVL subjects.
- Advocacy for ICT Integration: The findings may be shared with relevant stakeholders, including educators, policymakers, and industry partners, to promote greater investment in ICT infrastructure, digital tools, and instructional resources for TVL education.
- Monitoring and Evaluation Systems: The study could inform the development of assessment tools and monitoring mechanisms to evaluate the effectiveness of ICT-enhanced PBL interventions and support continuous improvement in teaching and learning practices.

The outcomes of the study are expected to contribute to broader educational improvements by fostering innovation and strengthening instructional practices. Ultimately, these efforts aim to empower students to develop critical thinking skills that are essential for their academic, professional, and personal growth.

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