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Development of an Instructional Manual in Electrical Installation and Maintenance for Enhancing Practical Competency in the TVL-Industrial Arts Track

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ABSTRACT

This study developed and validated an instructional manual for the Electrical Installation and Maintenance (EIM) module under the Technical-Vocational-Livelihood (TVL) strand of Philippine senior high schools. Guided by the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model, the manual was designed to address gaps in standardized instructional resources and to align with the Training Regulations of the Technical Education and Skills Development Authority (TESDA) for National Certificate II (NC II). A descriptive-developmental mixed-methods design was employed, combining expert validation and pretest-posttest experimental procedures. A total of 90 participants were involved, including teachers, industry professionals, and Grade 11 students. Findings revealed that the experimental group using the manual achieved a substantial mean gain of 4.73 in posttest scores compared to only 1.18 in the control group, confirming statistically significant improvement in competency ($p < 0.05$). Expert evaluation also rated the manual "Very Good" across domains such as instructional design, technical accuracy, and usability (overall mean = 3.71). The manual thus demonstrated its effectiveness in enhancing practical skills, reinforcing schematic knowledge, and supporting certification readiness. It further contributes by offering a standardized, competency-based instructional tool that can be adapted across similar programs. The study recommends integrating digital supplements, strengthening teacher training, and expanding modules for broader application and long-term industry alignment.

1 INTRODUCTION

The Enhanced Basic Education Act of 2013 (Republic Act 10533) institutionalized the K to 12 program in the Philippine education system to improve the employability and global competitiveness of graduates. Within this framework, the Technical-Vocational-Livelihood (TVL) strand was introduced to emphasize practical skills development, preparing learners for employment or entrepreneurship. Electrical Installation and Maintenance (EIM), under the Industrial Arts specialization, is particularly important as it equips students with competencies aligned with the Technical Education and Skills Development Authority (TESDA) National Certificate II (NC II).

Despite this reform, challenges remain in the delivery of EIM instruction. Many schools continue to face limited access to standardized teaching materials, inconsistencies in instructional practices, and weak alignment with TESDA standards. At

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Surigao del Norte National High School, for example, the absence of structured instructional aids has constrained students' ability to interpret technical drawings, a competency essential for NC II certification. These local challenges reflect broader concerns in technical-vocational education, where insufficient resources and fragmented implementation reduce student readiness for certification and employment (Ramos, 2021; Geraldizo & Dabasol, 2022).

International evidence shows that competency-based education supported by structured instructional materials significantly enhances vocational learning outcomes. In Indonesia, competency-based TVET models facilitated smoother transitions to employment (Suryanda et al., 2019), while in China, contextualized instructional tools improved both cognitive and practical performance (Huang et al., 2022). Similar trends are evident in the Philippines, where systematically designed modules based on the ADDIE model have strengthened employability and skill acquisition in vocational programs (Gabawa et al., 2024). Broader studies confirm that aligning technical education with sustainability and industry demands contributes to long-term employability and workforce readiness (Victoria et al., 2021; Sanchez et al., 2021).

Instructional materials play a dual role for both students and teachers. They serve as vehicles for exploration and problem-solving while also organizing complex technical knowledge into manageable learning tasks. Asad et al. (2021) emphasized their role in scaffolding learner engagement, while Boettcher and Conrad (2021) underscored their importance in structuring instruction. However, inconsistency in teacher-made resources remains a recurring issue. In the Philippines, many materials lack standardization and fail to align with TESDA competencies, resulting in uneven outcomes in EIM programs (Ramos, 2021; Geraldizo & Dabasol, 2022).

Local studies further highlight the value of structured training in EIM. Bulosan (2023) and Rosales (2022) found that contextualized EIM materials improved both technical proficiency and employability skills. Geraldizo and Dabasol (2022) reported that inadequate facilities and instructional guides limited certification readiness, while Garra and Baes (2023) showed that competency-based models improved student transitions into the labor market. Alarcon et al. (2024) emphasized the need for job-readiness to remain central in TVL pathways. These findings reinforce the importance of standardized, validated instructional manuals to support both student competence and employability.

The theoretical foundations of this study rest on Constructivist Learning Theory and Experiential Learning Theory. Constructivism views learning as an active process of building knowledge through problem-solving, underscoring the importance of structured guides in scaffolding tasks such as technical drawing interpretation (Peck, 2024). Kolb's experiential learning cycle highlights the value of reflection on practice, aligning directly with the laboratory-based activities embedded in EIM training. Operationally, the ADDIE instructional design model provides a systematic approach to content creation through its phases of analysis, design, development, implementation, and evaluation. Its effectiveness in ensuring pedagogical rigor and measurable outcomes has been confirmed in both local and international studies (Spatioti et al., 2022; Suryanda et al., 2019; Gabawa et al., 2024).

Although previous research confirms the effectiveness of competency-based instructional design in TVET (Suryanda et al., 2019; Huang et al., 2022; Victoria et al., 2021; Sanchez et al., 2021; Gabawa et al., 2024; Bulosan, 2023; Rosales, 2022; Ramos, 2021; Geraldizo & Dabasol, 2022; Garra & Baes, 2023; Alarcon et al., 2024; Asad et al., 2021; Boettcher & Conrad, 2021; Peck, 2024; Spatioti et al., 2022), few studies have developed standardized and validated manuals specifically tailored for EIM technical drawing interpretation. Teacher-made resources remain inconsistent, poorly structured, and insufficiently aligned with TESDA standards, limiting both teacher effectiveness and student certification readiness.

To address this gap, the present study aims to design, implement, and evaluate an ADDIE-based instructional manual for the "Interpret Technical Drawings and Plans" module of the EIM NC II program. The manual integrates theoretical grounding with laboratory-based activities, validated by teachers, students, and industry experts, to ensure content accuracy, technical quality, and alignment with TESDA standards. By providing a structured, outcomes-based, and industry-aligned instructional resource, this study seeks to improve student readiness for certification and contribute to the broader advancement of technical-vocational education in the Philippines.

1.1 Paradigm of the Study and Summary

The study adopts an Input–Process–Output (IPO) model (Fig. 1), which illustrates the systematic flow of competencies, processes, and outcomes in developing the instructional manual. The process began with the identification of core competencies, particularly technical drawing interpretation consistent with TESDA NC II standards, followed by design and development guided by the ADDIE instructional framework. Expert validation and pilot testing were integrated to ensure technical accuracy and pedagogical soundness. The primary output was a validated instructional manual aimed at improving students' competencies and readiness for national certification. A feedback loop was incorporated to enable continuous improvement, ensuring that revisions could be made based on assessments and user input.

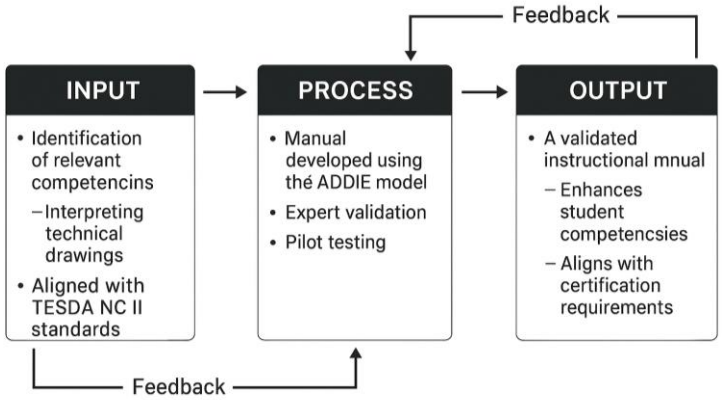

Fig. 1: Schematic Diagram

2 Methodology

2.1 Research Design

This study employed a descriptive–developmental design with a mixed-methods approach. The descriptive strand examined gaps in current Electrical Installation and Maintenance (EIM) instruction, while the developmental strand focused on designing, implementing, and validating an instructional manual using the ADDIE model. To evaluate effectiveness, an experimental pretest–posttest control group design was used to compare students taught with the developed manual (experimental group) against those taught using conventional methods (control group), with procedures in place to ensure baseline equivalence.

2.2 Participants and Sampling

Ninety participants were selected through purposive sampling, comprising Grade 11 EIM students, teachers, curriculum supervisors, and a TESDA-certified practitioner. Of the 162 Grade 11 EIM students at Surigao del Norte National High School, 82 were included and randomly assigned to the experimental ($n = 41$) and control ($n = 41$) groups, a process that promoted comparability at baseline. Sample size adequacy followed Cohen's (1988) guidelines for a medium effect ($d = 0.50$), $\alpha = 0.05$, and power = 0.80, indicating a minimum of 64 students; the final sample of 82 exceeded this threshold and provided sufficient statistical power to detect group differences.

2.3 Research Instruments

Three instruments were employed. An Evaluation Checklist adapted from DepEd Order No. 001, s. 2021 assessed content quality, instructional design, layout, language, assessment features, and TESDA alignment; internal consistency was excellent (Cronbach's $\alpha = 0.91$). Researcher-developed pretest and posttest measures evaluated knowledge of electrical drawings and application of EIM competencies; content validity was established by three experts, and pilot testing yielded reliable scores ($\alpha = 0.87$). Finally, survey and interview guides elicited qualitative feedback from students, teachers, and industry practitioners regarding the manual's clarity, usability, and industry relevance.

2.4 Experimental Design and Procedure

The procedure unfolded in sequential stages. First, expert validation was conducted, with subject heads, TESDA-certified electricians, and supervisors reviewing the initial manual for accuracy and alignment with NC II standards. Second, both groups completed a pretest; an independent t-test showed no significant difference ($p > 0.05$), confirming baseline equivalence. Third, during implementation, the experimental group used the developed manual in laboratory sessions while the control group followed traditional instruction. Fourth, both groups took a posttest to measure competency gains. Finally, surveys and interviews captured qualitative insights on strengths, limitations, and areas for improvement.

2.5 Data Analysis

Quantitative data were analyzed using descriptive statistics (means and standard deviations) to summarize expert evaluations and test scores, paired-sample t-tests to assess within-group pretest–posttest improvement, and independent-sample t-tests to compare posttest performance between groups. ANCOVA was applied to adjust for any pretest differences,

providing a more accurate estimate of relative learning gains. Qualitative responses were examined through thematic coding to identify patterns related to clarity, usability, and industry applicability.

2.6 Ethical Considerations

The study adhered to established ethical protocols in educational research. Informed consent was obtained from all respondents, with parental consent secured for minors. Confidentiality was protected through anonymized records, and participants were informed of their right to withdraw at any time. During laboratory activities, occupational safety requirements were observed in accordance with TESDA guidelines, with supervision by qualified teachers and practitioners.

3 Results and Discussion

3.1 Evaluation of the Instructional Manual

The instructional manual was evaluated by a panel composed of TVL subject heads, EIM teachers, TESDA-certified electricians, and the Education Program Supervisor (EPS) in TLE. Six domains were assessed: learning competencies, instructional design, instructional quality, assessment tools, readability, and compliance with intellectual property standards.

Table 1: Evaluation of the Instructional Manual by Experts

Evaluation Domain	Mean Score	Interpretation
Learning Competencies	4.00	Very Good
Instructional Design and Organization	3.58	Very Good
Instructional Quality	3.54	Very Good
Assessment Tools	3.71	Very Good
Readability	3.75	Very Good
Intellectual Property Compliance	3.67	Very Good
Overall Mean	3.71	Very Good

The results in table 1 show that the manual achieved a Very Good overall rating (M = 3.71). Evaluators noted that the manual was logically structured, aligned with TESDA NC II competencies, and reinforced both cognitive and psychomotor skills. The highest score was in learning competencies (M = 4.00), indicating that the manual successfully addressed the targeted skill set for students. Readability (M = 3.75) also received favorable remarks, with reviewers commending the clarity of instructions and step-by-step format.

To illustrate the evaluation more effectively, a bar chart is presented (Figure 1), showing the mean ratings across domains, which makes differences easier to interpret. Figure 2. Expert Evaluation of the Instructional Manual by Domain (Bar chart comparing mean scores for each domain: Learning Competencies, Instructional Design, Instructional Quality, Assessment Tools, Readability, Intellectual Property Compliance.)

These results in figure 2 are consistent with earlier studies highlighting the effectiveness of instructional materials developed using systematic design models. For example, Suryanda et al. (2019) reported that ADDIE-based modules significantly improved students' performance in science and engineering subjects, while Gabawa et al. (2024) found similar results in developing training programs for vocational courses. The strong evaluation ratings in this study confirm that structured instructional materials grounded in competency standards contribute to improved instructional quality and usability.

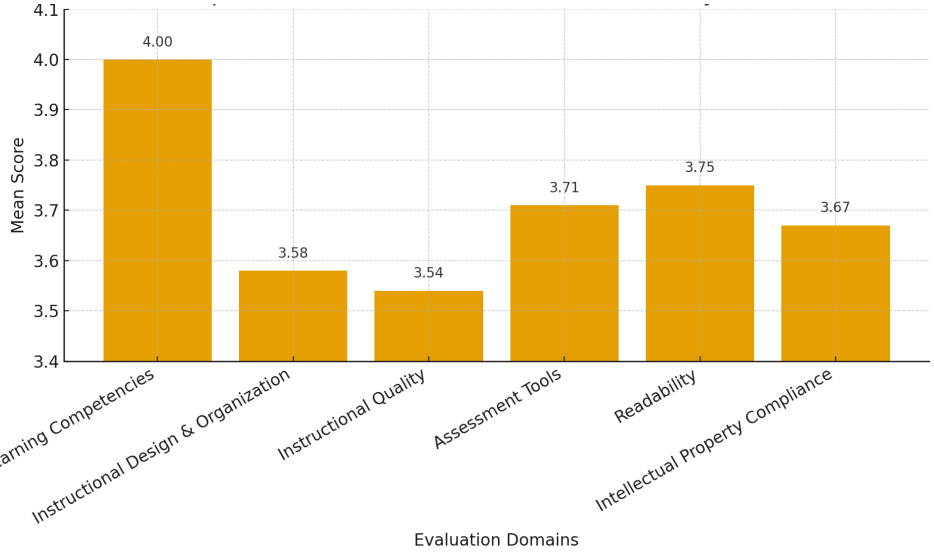

Fig. 2: Expert Evaluation of the instructional Manual by Domain

3.2 Pretest and Posttest Performance

Student learning outcomes were assessed using a pretest–posttest design for both the experimental and control groups. Baseline results showed that the two groups had comparable pretest scores, confirming their equivalence prior to the intervention. After implementation, however, a marked difference was observed. A paired t-test in table 2 confirmed a statistically significant gain in the experimental group ($p < 0.05$). In contrast, the control group showed only minimal improvement. An independent t-test comparing posttest results further revealed that students taught using the manual outperformed their peers taught through conventional methods, validating the manual's effectiveness in enhancing competencies.

Table 2: Comparison of Pretest and Posttest Scores

Group	Mean Pretest	Mean Posttest	Mean Gain	Interpretation
Control Group	12.40	13.58	1.18	Minimal Improvement
Experimental Group	12.32	17.05	4.73	Substantial Improvement

3.3 Thematic Analysis of Stakeholder Feedback

Qualitative feedback from students, teachers, and industry validators was analyzed thematically to complement the quantitative findings, revealing three major themes: (1) clarity and usability, where participants consistently described the manual as logically sequenced and easy to follow, with diagrams and real-world examples that made technical drawings more accessible; as one student noted, "The manual explained the steps in a way that I could understand and apply right away in practice," echoing Boettcher and Conrad's (2021) view that well-structured resources improve knowledge transfer in complex technical fields; (2) instructional efficiency and confidence, as teachers observed higher engagement and smoother laboratory sessions, while students reported greater confidence in wiring and installation tasks, consistent with Bulosan (2023) on the benefits of performance-based EIM materials; and (3) recommendations for improvement, where stakeholders proposed adding digital resources (e.g., video tutorials and interactive simulations), expanding coverage to advanced competencies, and incorporating troubleshooting activities, with industry validators emphasizing alignment with emerging workplace demands, mirroring Suryanda et al. (2019) on the need to continually update instructional modules. Overall, the qualitative evidence indicates that the manual is practical, user-friendly, and effective for classroom integration, while identifying clear avenues for innovation and broader applicability.

Table 3: Thematic Analysis of Stakeholder Feedback

Theme	Key Insights	Supporting Evidence
Clarity and Usability of the Manual	Manual was logically sequenced, easy to follow, with clear diagrams and real-world examples. Students found it accessible for learning technical drawings.	Student quote: "The manual explained the steps in a way that I could understand and apply right away in practice."; Boettcher & Conrad (2021)
Instructional Efficiency and Confidence Building	Increased student engagement and confidence in performing wiring and installation tasks; teachers noted more efficient laboratory sessions.	Bulosan (2023) reported similar improvement in engagement and mastery with structured materials.
Recommendations for Future Improvement	Suggestions included adding digital resources (videos, simulations), expanding coverage to advanced competencies, and workplace troubleshooting scenarios.	Aligns with Suryanda et al. (2019) on updating instructional modules to industry needs.

3.4 Integration with Curriculum and Standards

The developed instructional manual was evaluated not only for its effectiveness in improving student performance but also for its alignment with curriculum requirements and industry standards. Analysis confirmed that the manual corresponded closely with the TESDA National Certificate II (NC II) Training Regulations, particularly in the competency "Interpret Technical Drawings and Plans." Each lesson was mapped against the required elements of competency, ensuring consistency with assessment criteria for certification readiness.

The manual also complemented the Department of Education's (DepEd) K to 12 TVL curriculum, especially the MATATAG reform agenda, which emphasizes mastery of foundational skills, technical-vocational readiness, and employability. By integrating step-by-step procedures, safety protocols, and performance-based activities, the manual operationalized these policy priorities at the classroom level.

Beyond compliance, the manual strengthened the development of 21st-century skills such as problem-solving, critical thinking, and precision. Teachers reported that the manual not only improved technical competency but also promoted safety awareness and confidence in laboratory work. These outcomes mirror the findings of Victoria et al. (2021), who emphasized the importance of technical education in preparing learners for sustainable and future-oriented careers.

The integration of the manual with TESDA and DepEd standards underscores its role as a standardized instructional tool that addresses gaps in resource inconsistency across schools. In doing so, it contributes to improving certification readiness rates and enhancing employability among TVL graduates.

3.5 Discussion

The findings of this study demonstrate that the developed instructional manual significantly enhanced the competencies of Grade 11 students in Electrical Installation and Maintenance (EIM). Quantitative results showed a statistically significant improvement in the experimental group compared with the control group, confirming that structured instructional resources grounded in the ADDIE model are effective in bridging theory and practice. These findings validate Rafa's (2010) assertion that pretest–posttest approaches provide reliable evidence of instructional validity, and they are consistent with Suryanda et al. (2019), who reported that ADDIE-based modules improved vocational students' performance in technical subjects.

The expert evaluation further affirmed the manual's quality, rating it "Very Good" across all domains. This aligns with Gabawa et al. (2024), who emphasized that instructional materials designed with learner and industry needs in mind improve knowledge transfer and applicability. In this study, experts highlighted the manual's clarity, organization, and alignment with TESDA NC II standards, underscoring its potential as a standardized tool for EIM instruction.

The qualitative feedback reinforced these quantitative results. Students and teachers noted that the manual improved engagement, confidence, and comprehension of technical drawings, while industry validators stressed its workplace relevance. These outcomes echo Boettcher and Conrad's (2021) argument that structured instructional design fosters better understanding and skill application, particularly in technical disciplines. The recommendations to integrate digital tools and expand coverage also support Suryanda et al.'s (2019) claim that instructional materials must adapt continuously to evolving industry demands.

Importantly, this study contributes a novel dimension to TVET literature by focusing on a highly specific competency: interpreting technical drawings under the EIM NC II curriculum. While earlier studies (e.g., Rosales, 2022; Garra & Baes, 2023) examined broader TVL outcomes, few have systematically developed and validated an instructional manual targeting this competency. Thus, the present study addresses a gap by producing a standardized and empirically tested resource that directly supports certification readiness.

In sum, the results confirm that competency-based instructional manuals, when developed through systematic frameworks like ADDIE and grounded in constructivist and experiential learning theories, can substantially improve both learning outcomes and instructional quality. The study extends existing research by offering a replicable model for developing similar materials across other TVL competencies, thereby contributing to both practice and scholarship in technical-vocational education.

4 Conclusions, Limitations and Recommendations

4.1 Conclusions

This study developed, validated, and implemented an instructional manual for the Electrical Installation and Maintenance (EIM) module under the Technical-Vocational-Livelihood (TVL)–Industrial Arts strand, guided by the ADDIE model. Results demonstrated that students exposed to the manual achieved significantly higher posttest scores compared with those taught using conventional methods, confirming the manual's effectiveness in enhancing technical competencies. Expert evaluators rated the manual "Very Good" in terms of instructional design, technical accuracy, and usability, while qualitative feedback highlighted its clarity, practicality, and contribution to student confidence.

The study concludes that a systematically designed, competency-based instructional manual can effectively bridge theoretical knowledge with hands-on practice, thereby supporting student readiness for TESDA NC II certification. It further affirms that integrating constructivist and experiential learning principles into instructional design enhances engagement and performance in technical-vocational education.

4.2 Limitations

While the findings are promising, several limitations must be acknowledged. The study was conducted in a single public school, limiting the generalizability of results to other contexts. The evaluation focused on short-term outcomes, without tracking long-term impacts on NC II certification performance or workplace integration. Additionally, the manual was limited to the "Interpret Technical Drawings and Plans" competency and did not cover other advanced EIM topics such as troubleshooting or circuit design.

4.3 Recommendations

Institutions offering the TVL strand should consider adopting the manual to standardize instructional delivery in EIM, while ensuring alignment with TESDA standards.

Future versions of the manual may incorporate multimedia components, such as video tutorials, interactive simulations, and digital assessments, to expand accessibility and engagement.

In-service training programs should be developed to equip teachers with strategies for effectively integrating the manual into classroom and laboratory instruction.

Additional modules should be created to address advanced competencies in EIM, ensuring comprehensive preparation for NC II certification.

Replication studies in other schools and regions are recommended to test the manual's adaptability and effectiveness in diverse contexts. Longitudinal studies should also be conducted to measure its long-term effects on certification outcomes and employability.

Convert the manual into a digital format, incorporating videos, animations, and interactive simulations to enhance learner engagement and accessibility.

Provide training programs for EIM teachers on the effective use of the manual and its integration into laboratory instruction to ensure consistency in delivery.

Establish a feedback mechanism for continuous improvement of the manual based on inputs from students, teachers, and industry stakeholders.

Pilot the manual in other TVL institutions to validate its generalizability and impact across different school contexts and learner profiles.

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Credit Authorship Contribution Statement

Eviota, JDL.: Eviota was responsible for the design, content creation, and technical accuracy of the instructional manual for Electrical Installation and Maintenance. He developed the practical exercises and theoretical components, ensuring they align with industry standards and the practical needs of the TVL-Industrial Arts Track.

Gabawa, LM.: Gabawa was responsible for integrating the manual into the existing TVL curriculum and ensuring its pedagogical soundness. She conducted the evaluation of the manual's effectiveness in enhancing practical competency and performed the data analysis. She also led the drafting of the manuscript, including the sections on curriculum alignment, evaluation methodology, and results.

Ethical Statement

The authors confirm that this research was conducted in full compliance with the ethical standards set by the International Journal of Engineering Innovation and Dissemination (IJEID). All participants provided informed consent prior to their involvement, and approval was obtained from the relevant educational authorities. The study adhered to principles of transparency, confidentiality, and academic integrity, with all data reported honestly and all sources properly cited.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

The authors declare that the data supporting the findings of this study will be made available upon reasonable request.

AI Usage Disclosure

This manuscript utilized Grammarly and Gemini AI for language refinement and editorial suggestions. Grammarly was used to enhance grammar, clarity, and readability, while Gemini AI provided support in rephrasing and improving sentence structure. These tools were not used for generating original content, conducting data analysis, or interpreting research findings. The authors retain full responsibility for the scholarly integrity, originality, and intellectual contribution of this work.

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