

Electrical Installation and Maintenance Circuit Trainer for Senior High School

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Abstract

This study developed and evaluated an Electrical Installation and Maintenance (EIM) Circuit Trainer for senior high school students to support practical electrical competencies through an accessible and portable instructional device. Guided by instructional design principles and the Input-Process-Output framework, the study employed a quantitative developmental and descriptive research design involving 30 evaluator-respondents, comprising 15 Grade 11 EIM students and 15 teacher-experts at Bambang National High School, Nueva Vizcaya, Philippines, during the school year 2023–2024. Data were collected using an adapted 20-item, four-point Likert-scale questionnaire assessing design, functionality, cost-effectiveness, and safety. Mean scores and independent-samples t-tests were utilized for data analysis. The developed foldable, suitcase-type circuit trainer incorporated electrical components and reusable wire connectors to facilitate wiring installation, circuit assembly, maintenance, and troubleshooting, with a total fabrication cost of ₱24,191.75. Findings revealed a very high overall acceptability ($M = 3.41$), particularly in functionality ($M = 3.53$), design ($M = 3.47$), and safety ($M = 3.40$), while cost-effectiveness ($M = 3.24$) was rated highly acceptable. Significant differences between teacher-expert and student evaluations were established in design ($p < .001$), cost-effectiveness ($p = .011$), and safety ($p = .001$), but not in functionality ($p = .054$). The study concluded that the developed trainer was acceptable as an instructional resource for EIM practical activities. It recommends using affordable and locally available materials, strengthening stakeholder collaboration, and considering institutional replication and further technological improvements. The study supports Sustainable Development Goals 4 (Quality Education), 8 (Decent Work and Economic Growth), and 9 (Industry, Innovation and Infrastructure) by contributing to competency-oriented technical education and instructional innovation. Its potential sustainability contributions include improved institutional access to reusable training equipment, more flexible laboratory resource utilization, and support for technical workforce preparation, although actual learning improvements and long-term economic benefits were not measured.

Keywords: Circuit Trainer; Cost-Effectiveness; Electrical Installation and Maintenance; Instructional Innovation; Instructional Materials; Safety; Technical-Vocational Education

1. Introduction

Technical-vocational education plays an important role in developing practical competencies, technological proficiency, and occupational readiness among learners. In electrical installation and maintenance (EIM), effective instruction requires opportunities to apply theoretical knowledge through circuit assembly, wiring installation, equipment operation, and troubleshooting. However, limited access to appropriate instructional equipment can restrict practical training and create challenges in achieving competency-based learning objectives. Recent research emphasizes the importance of accessible, functional, and properly evaluated instructional trainers in supporting practical electrical education (Rosales, 2022; Bulosan, 2023; Sembiring et al., 2024). Responding

to these concerns, the present study focused on developing and evaluating a portable Electrical Installation and Maintenance Circuit Trainer for senior high school learners. The instructional device was designed to support essential EIM competencies through practical wiring exercises and maintenance activities while considering portability, functionality, affordability, and safety. Its development reflects the broader need for contextually appropriate instructional innovations that support technical education, institutional resource efficiency, and sustainable workforce preparation.

Technical-Vocational-Livelihood (TVL) education is an important component of Philippine senior high school education, providing learners with opportunities to acquire occupational knowledge and practical competencies. Within the EIM specialization, learners are expected to develop skills in selecting appropriate tools and materials, installing electrical wiring systems, assembling lighting circuits, and performing maintenance and troubleshooting activities. These competencies require instructional resources that allow students to connect classroom theories with practical applications. The Technical Education and Skills Development Authority (TESDA, 2023), through the National Technical Education and Skills Development Plan 2023–2028, emphasizes accessible, relevant, inclusive, and industry-responsive vocational training. This direction supports the development of instructional facilities and practical learning resources that can strengthen technical competencies and prepare learners for changing occupational requirements. Nevertheless, the availability and adequacy of training resources remain important considerations in technical education. Bulosan (2023) examined EIM instruction among TVL learners and emphasized the importance of assessing students' technical knowledge, practical skills, and understanding of safety procedures. Similarly, Limpangog and Caliba (2024) identified significant relationships between EIM competency indicators and students' academic performance, highlighting the relevance of foundational knowledge of electrical tools and materials. Instructional trainers provide a practical means of supporting competency-based instruction by allowing learners to perform wiring operations in a structured learning environment. Rosales (2022) reported favorable evaluations of an EIM instructional trainer in terms of effectiveness, workmanship, functionality, safety, and user-friendliness. These findings support the educational relevance of developing training devices responsive to learners' practical requirements. Accordingly, the present study developed a portable, foldable circuit trainer intended to support wiring installation, lighting circuit assembly, maintenance, and troubleshooting. The proposed design incorporated electrical components and reusable wire connectors within a compact instructional device suitable for classroom demonstrations and laboratory exercises.

Recent literature highlights several interconnected considerations in developing and evaluating electrical instructional trainers, particularly practical competency development, instructional design, accessibility of training equipment, functionality, safety, and alignment with occupational requirements. These considerations emphasize the importance of providing learners with appropriate instructional resources that facilitate the application of theoretical knowledge in practical electrical activities. In this regard, Rosales (2022) demonstrated the educational relevance of instructional trainers evaluated by learners and electrical practitioners, emphasizing their potential to support competency-based electrical education. Similarly, Xu et al. (2024) examined a virtual reality-based wiring learning platform and reported improvements in wiring-related learning outcomes, particularly when virtual activities complemented conventional practical instruction. These findings underscore the importance of structured learning experiences that provide opportunities for repeated technical exercises while considering the appropriateness of instructional approaches. Building on the importance of practical competency development, recent studies have also explored the design and construction of functional instructional trainers that respond to limitations in conventional laboratory equipment. Sembiring et al. (2024) developed a modular electrical installation trainer through a systematic process involving planning, construction, and feasibility evaluation among teachers and students. Likewise, Mansal (2025) developed a competency-based electrical wiring trainer incorporating residential and commercial installation applications, with particular attention to technical performance, operational safety, portability, and practical relevance. These studies demonstrate that instructional trainer development increasingly considers not only the demonstration of electrical principles but also the integration of practical activities that reflect actual technical and occupational requirements. Consequently, developing adaptable and functional training devices may help strengthen the alignment between classroom instruction and workplace-related competencies. In addition to functionality and instructional relevance, the accessibility and adequacy of training resources remain important concerns in technical-vocational education. Alinea (2022), through a thematic literature review, identified technical skill mismatches, deficiencies in transversal skills, and inadequate administrative support as significant dimensions of industry-practice gaps in vocational education. The review further emphasized the importance of curriculum responsiveness, instructional quality, and institutional support in strengthening Technical and Vocational Education and Training (TVET). In relation to these concerns, the development of compact and portable instructional trainers offers a practical approach to addressing limitations in laboratory space and equipment availability. Such innovations may provide educational institutions with additional opportunities to conduct hands-on activities while considering existing instructional resources and institutional constraints. Furthermore, the effectiveness of instructional equipment as a teaching resource requires careful consideration of its technical characteristics and operational safety. Rosales (2022) emphasized the importance of evaluating electrical instructional trainers according to effectiveness, functionality, workmanship, safety, and user-friendliness. Similarly, Bulosan (2023) highlighted the significance

of students' knowledge and application of electrical safety measures in EIM instruction. These findings indicate that instructional trainers should not only demonstrate electrical operations but should also provide appropriate conditions for supervised practical activities. Accordingly, evaluating the acceptability of electrical trainers in terms of design, functionality, cost-effectiveness, and safety is essential in determining their suitability for instructional applications. Beyond technical functionality and safety, instructional innovation also contributes to broader educational objectives, particularly the development of transferable competencies. Li and Zhu (2023) investigated factors influencing transferable skill development in blended project-based learning and identified instructional design, learner engagement, and learning experiences as important considerations. Their findings suggest that well-structured practical learning activities may provide opportunities for students to develop competencies applicable across different educational and occupational situations. Nevertheless, improvements in transferable skills and learning performance require direct empirical assessment and should not be inferred solely from favorable evaluations of instructional equipment. This distinction is particularly relevant when evaluating newly developed circuit trainers, as perceived acceptability and demonstrated learning effectiveness represent different educational outcomes. Taken together, the reviewed literature establishes the importance of developing electrical instructional trainers that integrate practical competency requirements, functional design, accessibility, operational safety, and instructional relevance. While existing studies provide evidence supporting the development and evaluation of electrical training equipment, they also highlight the need to consider specific learning environments, available institutional resources, and the perspectives of intended users. In this context, the present study contributes to the existing literature by developing and evaluating a portable Electrical Installation and Maintenance Circuit Trainer for senior high school students, focusing on its design, functionality, cost-effectiveness, and safety. Its contribution centers on determining the acceptability of the developed instructional device as a resource for practical electrical education rather than establishing direct improvements in students' academic performance or technical competencies.

At the local level, the study was conducted at Bambang National High School in Bambang, Nueva Vizcaya, where senior high school learners pursue the TVL specialization in Electrical Installation and Maintenance. The development of the circuit trainer was motivated by the need for instructional equipment that could accommodate practical wiring activities while considering laboratory space, equipment availability, and institutional resources. Within the Philippine context, the importance of EIM competency development is supported by recent empirical findings. Bulosan (2023) examined learners' knowledge and skills related to electrical installation and safety, while Limpangog and Caliba (2024) investigated relationships between electrical competencies and academic performance. These studies reinforce the relevance of practical and competency-oriented instruction within the TVL curriculum. At the policy level, TESDA (2023) identifies quality technical training, lifelong learning, workforce readiness, and responsiveness to industry requirements as strategic directions for Philippine TVET. More recent national evidence from Generalao et al. (2025) indicates that completion of vocational training does not automatically guarantee improved employment quality, underscoring the importance of addressing skills alignment and wider labor-market conditions. Internationally, UNESCO (2022) recognizes TVET as an important mechanism for strengthening employability, supporting inclusive socioeconomic development, and responding to technological transitions. Its strategy for 2022–2029 emphasizes the development of relevant technical competencies and the transformation of vocational education to meet evolving workforce demands. The broader importance of electrical competency development is also associated with the need for reliable electrical infrastructure. The International Energy Agency, International Renewable Energy Agency, United Nations Statistics Division, World Bank, and World Health Organization (2023) documented continuing global challenges in achieving universal electricity access. Although instructional trainer development does not directly increase electricity access, strengthening electrical education forms part of the wider process of developing a technically capable workforce. These local, national, and global considerations establish the relevance of instructional innovations that are accessible, technically appropriate, and responsive to the practical requirements of electrical education.

The study was guided by instructional design principles and an Input-Process-Output (IPO) conceptual framework. Instructional design emphasizes the systematic organization of learning resources, practical activities, and assessment procedures to support intended competencies. Li and Zhu (2023) provide a contemporary perspective through their investigation of the Presage-Process-Product model in blended project-based learning. Their findings illustrate how instructional conditions, learning processes, and learner engagement can contribute to educational outcomes. This perspective supports the importance of aligning instructional materials with the learning activities and competencies they are intended to facilitate. The present study operationalized this instructional design orientation through the IPO framework. The input consisted of senior high school EIM learning competencies, particularly the installation of electrical lighting systems, auxiliary outlets, and lighting fixtures, together with maintenance and troubleshooting requirements. The process involved planning, designing, constructing, testing, evaluating, and revising the circuit trainer. Evaluation concentrated on four characteristics: design, functionality, cost-effectiveness, and safety. These dimensions are consistent with the importance of technical and user-oriented assessment demonstrated in related trainer-development research (Rosales, 2022; Sembiring et al., 2024). The output was a developed and evaluated EIM circuit trainer intended for practical

instructional applications. Within this framework, acceptability was treated as an assessment of the instructional device rather than direct evidence of improved academic achievement or occupational competence.

Existing research has established the relevance of instructional trainers in supporting electrical education. Rosales (2022) evaluated an EIM instructional device using several acceptability criteria, while Sembiring et al. (2024) explored the development and feasibility of a modular electrical installation trainer. Xu et al. (2024) investigated technology-supported wiring instruction, demonstrating additional approaches for strengthening practical learning opportunities. Despite these developments, the suitability of an instructional trainer remains dependent on the particular curriculum, intended competencies, laboratory conditions, available resources, and characteristics of its users. Favorable evaluations reported in other educational settings do not necessarily establish the acceptability of a trainer designed for a specific senior high school environment. The present study addressed this contextual need by developing a compact, foldable, suitcase-type EIM circuit trainer that incorporated practical circuit exercises and reusable wire connectors. The design considered ease of transportation, storage requirements, circuit assembly, and repeated instructional use. Specifically, the study sought to determine the materials, cost requirements, technical specifications, and design necessary for constructing the trainer; assess its acceptability in terms of design, functionality, cost-effectiveness, and safety; and determine whether significant differences existed between the evaluations of student and teacher-expert respondents. The study therefore contributes a context-specific evaluation of an instructional device intended to address practical training requirements at Bambang National High School. Its contribution lies primarily in the development and acceptability assessment of the trainer. The research does not establish causal improvements in student achievement, technical skill acquisition, certification performance, or long-term economic benefits.

The study is primarily aligned with Sustainable Development Goal 4 (SDG 4): Quality Education, particularly Target 4.3, which promotes access to affordable and quality technical and vocational education, and Target 4.4, which emphasizes relevant skills for employment and entrepreneurship. UNESCO (2022) recognizes vocational education as an important component of inclusive learning and workforce development. By developing a practical instructional device suited to EIM competencies, the study contributes to efforts to improve the availability and relevance of technical learning resources. In addition to that, the study also supports the broader objectives of SDG 8: Decent Work and Economic Growth, particularly the development of occupational competencies relevant to productive employment. TESDA (2023) emphasizes workforce readiness and industry-responsive training as central components of national skills development. Although the present study did not measure employment outcomes, the development of practical EIM instructional resources is consistent with efforts to strengthen technical preparation. A secondary alignment exists with SDG 9: Industry, Innovation and Infrastructure, particularly through the development of a functional instructional innovation that responds to local educational requirements. The circuit trainer represents an applied technological development intended to improve access to practical training equipment, although broader industrial or infrastructural impacts were not evaluated.

The study contributes to multidisciplinary sustainability principally through educational, technological, socioeconomic, and institutional dimensions. From an educational sustainability perspective, the development of an EIM circuit trainer supports the continued provision of competency-based instruction by offering a reusable resource for supervised practical exercises. This direction is consistent with the Global Education Monitoring Report Team (2023), which emphasizes that educational technologies should be appropriate, equitable, and sustainable in relation to learners' needs and institutional conditions. Regarding technological sustainability, the trainer demonstrates the application of instructional design and locally adaptable equipment development to practical electrical education. Its compact and portable configuration offers a potential alternative for institutions facing space and equipment constraints. However, its long-term durability and maintenance requirements would need further assessment. In terms of socioeconomic sustainability, the study supports the broader objective of preparing learners for technical occupations through curriculum-relevant practical instruction. Alinea (2022) emphasizes the importance of reducing industry-practice gaps, while TESDA (2023) identifies skills development as an important component of national socioeconomic transformation. The trainer's contribution is therefore associated with technical learning opportunities rather than demonstrated employment or income effects. From an institutional and resource sustainability perspective, the use of a portable trainer with reusable electrical connections may support repeated instructional activities and more flexible use of laboratory facilities. These characteristics suggest potential resource-management advantages, although actual material savings, environmental benefits, and lifecycle costs were not directly measured. Overall, the study demonstrates how contextually appropriate instructional equipment can contribute to technical education and institutional capacity. By integrating practical competency requirements with considerations of functionality, cost, portability, and safety, it offers an instructional innovation relevant to the continuing development of accessible and sustainable vocational education.

2. Material and methods

2.1 Research Design

The study utilized a quantitative developmental and descriptive research design. The developmental approach focused on designing, constructing, testing, and evaluating an EIM circuit trainer intended to support practical learning competencies. According to Creswell and Creswell (2023), quantitative research involves systematic procedures for collecting and analyzing numerical data, while developmental research emphasizes the iterative design and evaluation of instructional products (Ibrahim, 2016). The descriptive approach was employed to determine respondents' assessments of the developed trainer without establishing causal relationships, consistent with Sirisilla (2023). The evaluation followed the research instrument adapted from Laboga and Rosales (2022), focusing on design, functionality, cost-effectiveness, and safety.

2.2 Locale of the Study

The study was conducted at Bambang National High School in Bambang, Nueva Vizcaya, Philippines, during the school year 2023–2024. The institution offers the Technical-Vocational-Livelihood (TVL) track, including Electrical Installation and Maintenance, to senior high school learners. The school served as the research setting for evaluating the developed circuit trainer in relation to the practical instructional requirements of the EIM specialization.

2.3 Respondents of the Study

The study involved 30 evaluator-respondents consisting of 15 Grade 11 EIM students from Bambang National High School and 15 electrical teacher-experts, with each group representing 50% of the respondents. These groups evaluated the instructional trainer based on its design, functionality, cost-effectiveness, and safety. The original sample-size discussion referred to Cudia et al., (2015) as cited by Mendoza (2020).

2.4 Sample and Sampling Procedure

Stratified random sampling was employed in selecting the 15 student respondents. The list of eligible EIM students was obtained from the school principal's office, and a lottery procedure was used to identify the participants. The study also included 15 electrical teacher-experts as evaluators. The original methodology did not specify the procedure used to select the teacher-experts.

2.5 Research Instrument

The study utilized an adapted evaluation questionnaire based on the research instruments of Laboga (2022) and Rosales (2022). The instrument consisted of 20 items distributed equally across four evaluation dimensions: design, functionality, cost-effectiveness, and safety, with five items assigned to each dimension. A four-point Likert-type scale was used, with responses interpreted as Very High (3.25–4.00), High (2.50–3.24), Low (1.75–2.49), and Very Low (1.00–1.74). The questionnaire was presented to the research adviser and panel members for suggestions and validation. The methodology also specified evaluation by five experts to assess the instrument's validity and reliability.

2.6 Data Gathering Procedure

Data collection followed four stages involving planning, development, evaluation, and analysis. During the planning stage, the researcher identified the instructional requirements, prepared the circuit trainer's design and specifications, and developed the evaluation instrument. The development stage involved constructing the instructional trainer, testing its functionality and safety, and making necessary modifications to improve its operational performance. After preparation and assessment of the instrument, the developed trainer and evaluation questionnaires were presented to the 15 teacher-experts and 15 Grade 11 EIM students. During the final stage, the respondents' ratings were collected, organized, tabulated, and interpreted to determine the acceptability of the developed instructional device.

2.7 Data Analysis Techniques

The collected data were analyzed using descriptive and inferential statistical techniques. The mean was employed to determine the respondents' level of evaluation of the circuit trainer in terms of design, functionality, cost-effectiveness, and safety. An independent-samples t-test was used to determine whether significant differences existed between the evaluations of the teacher-experts and student respondents across the four dimensions. All statistical tests were evaluated at a 0.05 level of significance.

2.8 Ethical Considerations

The study considered the protection and confidentiality of the respondents throughout the research process. Participants were not subjected to procedures intended to cause physical or psychological harm, and the privacy and confidentiality of the information collected through the evaluation questionnaires were maintained.

3. Results and Discussion

3.1 Profile of the respondents Development of the Electrical Installation and Maintenance Circuit Trainer

3.1.1 Materials, Specifications, and Cost Requirements

The developed EIM circuit trainer incorporated electrical and structural components necessary for performing practical wiring activities. The principal components included circuit breakers rated at 15, 20, 30, and 60 amperes; a panel board; digital submeter; magnetic contactor; switches; convenience and special-purpose outlets; lighting fixtures; electrical wires; WAGO wire connectors; PVC conduits; junction boxes; and protective accessories. The supporting structure was constructed using marine plywood, hinges, handles, locks, and caster wheels. The materials cost ₱14,615.00, while labor was estimated at ₱6,576.75, equivalent to 45% of material expenses. Additional miscellaneous expenses amounted to ₱3,000.00, resulting in a total fabrication cost of ₱24,191.75. The cost breakdown identifies the resources required to construct the instructional device and provides a basis for assessing its affordability in relation to institutional training requirements. The inclusion of multiple electrical components allows the trainer to accommodate different practical exercises within one instructional assembly. Similarly, Sembiring et al. (2024) emphasized the development of modular electrical installation trainers to address limitations in conventional laboratory equipment. Mansal (2025) also considered economic and technical requirements in developing an electrical wiring trainer, reinforcing the importance of integrating instructional functionality with resource considerations. However, the reported fabrication cost alone does not establish economic superiority over commercially available alternatives.

3.1.2 Design and Operational Features of the Circuit Trainer

The developed circuit trainer featured a portable, foldable, suitcase-type configuration measuring 46 inches in length when fully opened and 23 inches when folded. Its total height was 31.7 inches, including a 30-inch main frame and 1.7-inch caster wheels. The device incorporated carrying handles, a supporting stand, protective enclosures, and reusable wire connectors. Its electrical components were arranged to accommodate practical exercises involving lighting circuits, convenience and special-purpose outlets, switching operations, motor controls, and troubleshooting. The trainer underwent assembly, operational testing, revisions, and final testing before evaluation by students and teacher-experts. The foldable configuration was intended to address limited laboratory space and facilitate the transportation and storage of instructional equipment. Reusable wire connectors were incorporated to reduce the need for repeated cutting and splicing during wiring activities. These design characteristics reflect the importance of adaptable and competency-oriented instructional devices. Sembiring et al. (2024) similarly developed an electrical installation trainer designed for laboratory activities, while Samonte (2025) demonstrated the relevance of incorporating practical electrical components and troubleshooting functions into instructional trainers. The present findings establish the constructed device's configuration and intended instructional applications, although its long-term durability and operational efficiency were not separately measured.

3.2 Level of Acceptability of the Developed Circuit Trainer

3.2.1 Overall Evaluation of Teacher-Experts and Students

The developed EIM circuit trainer obtained an overall grand mean of 3.41, interpreted as a very high level of acceptability. Teacher-experts recorded a grand mean of 3.72, indicating very high acceptability, while student respondents obtained a grand mean of 3.10, indicating high acceptability. Across the four evaluation dimensions, functionality received the highest overall mean of 3.53, followed by design at 3.47, safety at 3.40, and cost-effectiveness at 3.24. Teacher-experts consistently assigned higher ratings than students across all dimensions. These findings indicate favorable perceptions of the developed trainer's suitability as an instructional device, particularly in terms of its operational characteristics. Rosales (2022) similarly reported favorable evaluations of an EIM instructional trainer based on effectiveness, workmanship, functionality, safety, and user-friendliness. Samonte (2025) also evaluated an industrial motor controls trainer using technical and instructional acceptability criteria. The present results support the trainer's perceived instructional suitability; however, acceptability ratings should not be interpreted as direct evidence of improved academic achievement or practical competency.

3.2.2 Functionality of the Circuit Trainer

Functionality obtained the highest overall mean of 3.53, indicating very high acceptability. Teacher-experts assigned a mean of 3.77, while student respondents recorded 3.28, both classified as very high. The findings indicate that both evaluator groups positively assessed the trainer's capability to perform its intended electrical installation and maintenance functions. The favorable functionality ratings suggest that the developed device was perceived as suitable for demonstrating electrical circuits and conducting practical wiring activities. Rosales (2022) similarly identified functionality as an important criterion in evaluating EIM instructional trainers. Moreover, Sembiring et al. (2024) emphasized the importance of developing electrical installation trainers capable of supporting laboratory exercises. These findings reinforce the relevance of functional instructional equipment in competency-based electrical education, although the present evaluation did not directly quantify improvements in student performance.

3.2.3 Design of the Circuit Trainer

Design obtained an overall mean of 3.47, interpreted as very high acceptability. Teacher-experts recorded a mean of 3.83, while students obtained 3.12, indicating very high and high acceptability, respectively. These results demonstrate favorable assessments of the trainer's physical arrangement, portability, component placement, and overall instructional configuration, with higher ratings provided by the teacher-experts. The findings suggest that the trainer's design was generally considered appropriate for practical electrical instruction. Its foldable structure and organized component arrangement were intended to accommodate laboratory activities while addressing storage and transportation requirements. Sembiring et al. (2024) similarly emphasized the importance of designing electrical installation trainers according to laboratory learning needs. Mansal (2025) also examined technical and operational considerations in developing competency-based electrical wiring equipment, supporting the relevance of systematic product design in instructional trainer development.

3.2.4 Safety of the Circuit Trainer

Safety obtained an overall mean of 3.40, indicating very high acceptability. Teacher-experts assigned a mean of 3.75, while student respondents recorded 3.05, corresponding to very high and high acceptability, respectively. The trainer incorporated protective enclosures, circuit breakers, secured electrical connections, and other components intended to support safe operation during practical instructional activities. The favorable safety ratings indicate that respondents generally perceived the device as suitable for supervised instructional use. Rosales (2022) likewise identified safety as an essential evaluation criterion for electrical installation and maintenance trainers. Samonte (2025) further emphasized safety considerations in developing instructional equipment for industrial motor control applications. Nevertheless, respondents' favorable perceptions of safety do not independently establish compliance with applicable electrical codes, technical standards, or certification requirements.

3.2.5 Cost-Effectiveness of the Circuit Trainer

Cost-effectiveness obtained the lowest overall mean of 3.24, interpreted as high acceptability. Teacher-experts recorded a mean of 3.53, indicating very high acceptability, while student respondents obtained 2.95, indicating high acceptability. Despite receiving the lowest rating among the four dimensions, cost-effectiveness remained positively evaluated by both groups. The total fabrication cost of ₱24,191.75 reflected the combined expenses for materials, labor, and miscellaneous requirements. These results indicate that respondents generally considered the trainer acceptable in terms of cost, although its affordability received comparatively lower ratings than its other characteristics. The findings suggest the importance of considering material selection and resource requirements when developing instructional equipment. Samonte (2025) similarly examined cost-effectiveness in developing an industrial motor controls trainer, while Mansal (2025) incorporated economic considerations into the evaluation of a competency-based wiring trainer. The present findings reflect perceived cost-effectiveness rather than a formal economic evaluation involving alternative equipment, lifecycle expenses, or quantified financial savings.

3.3 Differences Between Teacher-Expert and Student Evaluations

3.3.1 Significant Differences in Design, Cost-Effectiveness, and Safety

The independent-samples t-test revealed significant differences between teacher-expert and student evaluations in terms of design ($t = 7.44$, $p < .001$), cost-effectiveness ($t = 2.76$, $p = .011$), and safety ($t = 3.57$, $p = .001$). The overall comparison also indicated a significant difference ($t = 6.04$, $p < .001$). All significant results were below the 0.05 level of significance. Consequently, the null hypothesis was rejected for these evaluation dimensions and for the overall comparison. Teacher-experts recorded higher mean ratings than students across the three dimensions. These findings indicate that the two respondent groups differed in their assessments of selected instructional trainer characteristics. The differences may reflect variations in their perspectives and experience with electrical training equipment, although these explanations were not directly tested in the study. Rosales (2022) demonstrated the relevance of involving both learners and electrical practitioners in instructional trainer evaluation, while Samonte (2025) incorporated assessments from students, faculty members, and electrical practitioners in evaluating an industrial motor controls trainer. The present findings emphasize the value of considering evaluations from different user groups when assessing the suitability of technical instructional devices.

3.3.2 Non-Significant Difference in Functionality

The evaluation of functionality produced a computed t-value of 2.01 and a p-value of .054, which exceeded the 0.05 significance level. Therefore, no statistically significant difference was established between the teacher-expert and student evaluations of the trainer's functionality. Although teacher-experts recorded a higher mean of 3.77 than students at 3.28, the statistical result did not provide sufficient evidence to reject the null hypothesis for this dimension. Both groups classified functionality as very highly acceptable. This finding indicates that both evaluator groups provided favorable assessments of the trainer's functionality despite differences in their numerical ratings. The result is consistent with the general importance assigned to operational suitability in instructional trainer development, as discussed by Rosales (2022) and Sembiring et al. (2024). The absence of a statistically significant difference should not be interpreted as proof that the two groups held identical opinions;

rather, the study did not establish a significant difference in their functionality evaluations at the specified significance level.

4. Conclusion & Recommendations

The study successfully developed an Electrical Installation and Maintenance (EIM) Circuit Trainer capable of demonstrating practical competencies in electrical wiring, lighting installation, outlet connections, motor control, and troubleshooting. The portable, foldable instructional device obtained an overall acceptability mean of 3.41, indicating very high acceptability, particularly in functionality (3.53), design (3.47), and safety (3.40), while cost-effectiveness (3.24) was rated highly acceptable. Significant differences were found between teacher-expert and student evaluations in terms of design, cost-effectiveness, and safety, whereas no significant difference was established in functionality. Overall, the findings demonstrate the acceptability of the developed circuit trainer as an instructional resource for practical electrical installation and maintenance activities.

The study recommends using affordable, recycled, and locally available materials to reduce the fabrication cost of the EIM circuit trainer without compromising its intended functionality and safety. Collaboration with electrical industries, educational institutions, laboratory workshops, and community stakeholders is encouraged to further improve its design, quality, and instructional applicability. School administrators may consider replicating and producing the trainer to address shortages of practical training equipment, while intellectual property protection may be pursued for the developed device. Future researchers are encouraged to develop more advanced instructional trainers incorporating emerging technologies to support the evolving requirements of technical-vocational education.

The study was limited to the development and acceptability evaluation of the EIM circuit trainer at Bambang National High School during the school year 2023–2024, involving 15 teacher-experts and 15 Grade 11 EIM students. The evaluation focused exclusively on design, functionality, cost-effectiveness, and safety. Consequently, the findings reflect the assessments of the selected respondents and do not establish the trainer's effectiveness in improving academic performance, practical skill acquisition, or long-term learning outcomes.

5. Compliance with ethical standards

The researcher affirms that no conflicts of interest exist in relation to this study. The research was conducted in accordance with ethical principles applicable to educational research involving human participants. The study involved 15 Grade 11 Electrical Installation and Maintenance (EIM) students and 15 teacher-experts who evaluated the developed circuit trainer in terms of design, functionality, cost-effectiveness, and safety. Appropriate measures were observed to protect respondents from physical and psychological harm, particularly during the evaluation and demonstration of the electrical instructional device. The privacy and confidentiality of respondents' information were maintained throughout data collection, analysis, and reporting. Student participants were selected through a lottery-based sampling procedure, and evaluation results were presented in aggregated form to protect individual responses.

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