DEMONSTRATION MODEL FOR WIRING A FOUR-WAY SWITCH CONTROL IN ELECTRICAL INSTALLATION AND MAINTENANCE

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Abstract

In the modern world, electrical systems form the backbone of daily life, powering everything from household appliances to complex industrial machinery. The efficiency, reliability, and safety of these systems depend greatly on proper wiring. However, a persistent challenge in vocational education is the lack of adequate training devices that realistically simulate professional electrical installations. A cost-effective, self-produced training model offers a viable solution to this problem.
At present, only 69% of students demonstrate proficiency in wiring electrical systems, highlighting the need for improved instructional tools. To address this gap, this study developed a demonstration model for wiring a four-way switch control, designed to enhance electrical installation and maintenance training for senior high school students. The study employed a descriptive-developmental research design, following a structured process of creation, refinement, and evaluation of the improvised model. Two senior high schools offering Electrical Installation and Maintenance programs were identified as research sites. Findings revealed that the developed wiring model is both accurate and highly suitable for instructional use. Its user-friendly design successfully captured students' attention, resulting in high levels of satisfaction and positive engagement. Evaluation results showed that most respondents rated the model as excellent, confirming its effectiveness and educational value. Both experts and students assessed the model as highly acceptable in terms of usability, effectiveness, and relevance to technical education. Statistical results further support these findings: Experts ($M = 4.90$, $SD = 0.14$) rated the model significantly higher than students ($M = 4.59$, $SD = 0.65$), $t = 4.350$, $df = 28.157$, $p < 0.001$. The significant p-value indicates that the difference in evaluations was statistically meaningful rather than due to chance. Normal distribution and t-test results confirm the robustness of the analysis. In conclusion, the developed demonstration model proves to be an effective, practical, and highly acceptable instructional tool for improving students' competency in electrical wiring installation.

Keywords: Electrical Installation and Maintenance; Demonstration Model; Four-Way Switch Wiring; Vocational Education; Technical Training

1. Introduction

In the modern world, electrical systems serve as the backbone of daily life, powering everything from household appliances to complex industrial machinery. The efficiency, reliability, and safety of these systems largely depend on proper wiring, which requires careful planning, adherence to codes, and proficient execution (Matos, 2024). As a response to the growing demand for skilled electricians, the

Electrical Installation and Maintenance National Certificate II (EIM NC II) has been established as one of the key specializations within the Technical-Vocational and Livelihood (TVL) Track–Industrial Arts Strand. This specialization, offered in most public senior high schools in the Philippines, equips students with the necessary competencies to become certified electricians by passing the National Assessment under the Technical Education and Skills Development Authority (TESDA) (Rosales, 2022). However, challenges such as the rising costs of materials essential for practical training hinder students from fully acquiring hands-on experience.

Electrical installation and maintenance remain in high demand within the industry, emphasizing the need for practical, technology-driven learning. Educators play a crucial role in ensuring that students receive hands-on training that closely replicates real-world industry settings. However, a major challenge in vocational education is the scarcity of adequate training devices that accurately simulate professional electrical installations. As a result, instructors often resort to improvising equipment to provide students with the necessary hands-on experience (Bernaldez, R. R., 2015).

One viable solution to this issue is the development of cost-effective, self-produced training models. Self-production offers financial advantages, as creating instructional models rather than purchasing commercial alternatives reduces costs significantly (Saini, 2025). Additionally, self-production fosters technological innovation and direct control over the learning process (Mazzarella & Peruccio, 2013). This study proposed the development of a demonstration model for wiring a four-way switch control system, ensuring that the materials and equipment used align with the competency standards required by the Electrical Installation and Maintenance NC II program.

Currently, on the level of competency in performing required skill as to installing electrical wiring connection, only (69%) percent of students demonstrate proficiency in wiring an electrical system (Limpangog, 2024). This highlights the critical role of demonstration technology in enhancing student learning and skill application. Demonstration-based learning facilitates knowledge retention and practical comprehension by allowing students to observe, replicate, and refine technical processes (Kondakciu, K., 2020). Research suggests that demonstration is particularly effective in teaching complex psychomotor and cognitive skills, especially in technology-rich environments that incorporate simulation-based learning (Weaver, 2015; Quinn, 2000). By developing a demonstration model for four-way switch control, it can provide an effective hands-on learning tool that enhances students' technical skills, promotes self-sufficiency in training, and bridges the gap between theoretical knowledge and practical application in electrical installation and maintenance.

1.1. Objectives of the study

This study developed a demonstration model for wiring a four-way switch control to enhance electrical installation and maintenance training for senior high school students.

Specifically, it sought to answer the following:

1.1.1 Design and develop a demonstration model for wiring a four-way switch control for electrical installation and maintenance.

1.1.2 Evaluate the developed demonstration model for wiring a four-way switch control for electrical installation and maintenance.

1.1.3. Determine the level of acceptability of the developed demonstration model for wiring a four-way switch control for electrical installation and maintenance.

2. Review of Related Literature

2.1 Developing students' psychomotor skill

Ezenwafor et al. (2020), Electrical trade in technical institutions provides learners with the knowledge and practical skills required to become effective and efficient technicians in the field. The program is expected to develop psychomotor skills in installing, operating, maintaining, and repairing electrically energized systems. There is a need for effective teaching in electrical installation and maintenance work because anything less would cause a threat to the lives and properties of users and also worsen unemployment.

2.2 Multi-Purpose Electrical Circuit Demonstration Trainer

Antonio (2020), Technology education program as an integral part of the Philippine education system is responsible for the level of formal education that focuses on the creation of skilled workers and technicians with adequate skills, attitudes and skills for different types and technology levels. Relative to the scenario of the present educational system as well as the need for our country to become globally competitive, students should be trained to the utmost of their capabilities through the use of modern instructional materials and models which plays a vital role in the attainment of the goals and objectives of technology education. In classroom situation, exposure of students to actual laboratory activities is very limited.

2.3 Wiring Installation Trainer

Pereyras, J. G. (2020) Electrical Wiring Installation Trainer taught students different installation and maintenance methods for Philippine Electrical Code (PEC)-based residential, commercial and even industrial electrical systems. This trainer brought to the classroom real-world experience working with and installing countless electrical equipment that were used in work locations.

2.4 Physics students' acquisitions of entrepreneurial skills in household electrical circuit sketch and wiring.

Uduak & Onwiodukit, (2019) The study of physics has continued to be of tremendous importance to the human society because of its central role in solving human societal problems. Notable areas where physics is crucial in providing solutions to the problems of the society include household electrical circuit sketch, wiring, safety and creation of jobs, among others. Several households suffer from several electrical damages, inconsistent power supply, high number of unemployment, as well as several electrical circuits related domestic problems which predicts low level of electrical circuit sketch, wiring skills and entrepreneurial development.

2.5 Students' conceptual understanding of electric circuits of introducing virtual manipulatives.

Zacharia & Jong, (2014), Instructional systems design (ISD), is the practice of systematically designing, developing and delivering instructional materials and experiences, both digital and physical, in a consistent and reliable fashion toward an efficient, effective, appealing, engaging and inspiring acquisition of knowledge. The process consists broadly of determining the state and needs of the learner, defining the end goal of instruction, and creating some "intervention" to assist in the transition.

3. Methodology

3.1 Research Design

This study employed a descriptive developmental research design, integrating a structured process that involves the creation, refinement, and evaluation of an improvised demonstration model for wiring a four-way switch control. The study begins with the design phase, in which the initial version of the model is conceptualized based on pedagogical needs and relevant literature. It then undergoes pilot testing with students and experts in Electrical Installation and Maintenance (EIM) to gather feedback on its design, usability, clarity, safety, functionality, and effectiveness in facilitating learning.

3.2 Creation of a demonstration model

The model follows several stages to achieve the desired outcome. The first stage is the design phase, the researcher uses a 3D software to create the design which illustrates the structure and initial appearance of the model. This phase involves consultations to ensure that the model aligns with the needs of the end users and relevant literature findings before proceeding to actual construction and assembly.

It is crucial to carefully select materials and devices that meet the required competency standards for electrical installation and maintenance. The illustration below outlines the components, their placement, and the structural measurements, serving as the researcher's guide in developing the training model for wiring. Once the design and construction are completed, the model undergoes a series of tests and performance evaluations to ensure its strength, quality, and safety, as well as to identify potential issues. To enhance practical application, students are then engaged in hands-on activities using the developed model. The developmental aspect of this research emphasizes the continuous improvement of instructional materials by refining the demonstration model based on user feedback and assessment results.

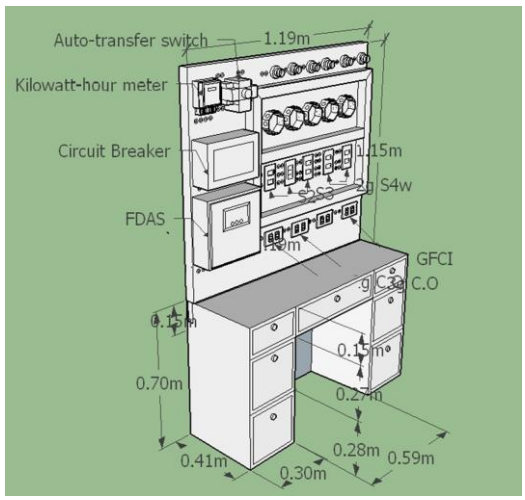

Figure 1. The design of demonstration model for wiring.

3.3 Participants

The study was conducted in two public secondary schools in Samar. The first is Clarencio Calagos Memorial School of Fisheries in Barangay Monbon, Sta. Margarita, which offers Technical-Vocational programs under the TLE curriculum in junior high school and senior high school programs under both the Academic and TVL tracks, including Electrical Installation and Maintenance (EIM). The second school is Ramon T. Diaz National High School in Barangay Adela Heights, Gandara, which also offers senior high

school programs, with the TVL track featuring Electrical Installation and Maintenance as one of its in-demand specializations. Students enrolled in the EIM course from these two schools served as the primary participants of the study.

3.4 Research Instrument

The survey utilizes a 5-point Likert scale, The questionnaire focusses on key areas of acceptability, including clarity and assembly of the wiring diagram, safety considerations, functionality, demonstration flow, and the visual and interactive elements of the model.

3.5 Data Gathering

The researcher first secured approval from the school administration and obtained informed consent from both students enrolled in Electrical Installation and Maintenance (EIM) and their teachers. A pre-orientation was conducted to explain the study's purpose, procedures, and confidentiality measures. Data collection began with the presentation of the research instrument, followed by a demonstration of the activity to ensure participants' understanding and safety. After the demonstration, participants evaluated the model by answering a survey based on their experiences. Data were collected during scheduled school visits, verified for completeness and accuracy, and stored securely for analysis.

3.6 Statistical Treatment of Data

The study employed descriptive and inferential statistics to analyze the survey data. Descriptive tools such as mean, standard deviation, percentage, and frequency count were applied to summarize, describe, and interpret the collected responses. The mean measured the central tendency of scores, while the standard deviation indicated the variability and consistency of responses. Percentages and frequency counts presented proportions and distributions of data, making group comparisons easier. For inferential analysis, the t-test was used to determine whether differences between group means were statistically significant. Collectively, these statistical methods ensured objective, reliable, and meaningful interpretation of the data, supporting the evaluation of the developed demonstration model in electrical installation and maintenance.

3.7 Ethical Considerations

The study adhered to ethical standards to ensure respect for the rights of all participants. Participation was entirely voluntary, and informed consent was obtained prior to involvement, ensuring that participants were fully aware of the study's purpose, procedures, potential risks, and benefits. The study was reviewed and granted a clearance by the Samar State University Research Ethics Committee, which assessed the research design to ensure full compliance with established ethical standards for studies involving human participants.

4. Results

4.1 The Designed and developed Demonstration model for wiring a four-way switch in electrical installation and maintenance.

The developed demonstration model proved to be an effective tool for simplifying complex concepts in electrical installation and maintenance, thereby enhancing student learning. The design process, guided by sketches and 3D modeling software, resulted in an innovative, user-friendly, and engaging instructional

device. The completed model was constructed with durable materials, ensuring stability and reliability during use. Its aesthetic finish, painted in a clean white tone, added visual appeal that captured student attention. Furthermore, the addition of a roller provided mobility, making the model convenient to transport between classrooms. Overall, the final output successfully met the intended purpose of serving as both an instructional aid and a practical training model.

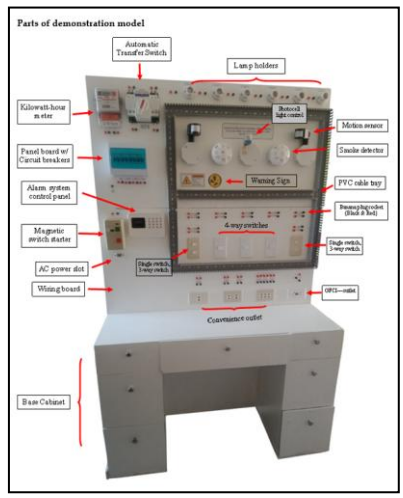

Figure 2. The actual appearance of demonstration model for wiring.

4.2 *Evaluation of developed demonstration model for wiring*

The findings shed light on the respondents' satisfaction levels, highlighting the effectiveness and impact of the demonstration model on their overall experience. The results particularly emphasize key evaluation elements, including the clarity and assembly of the wiring diagram, safety considerations, functionality, demonstration flow, and the quality of visual and interactive elements

Table 1. Summary of the evaluation elements

Elements	Mean	SD	Interpretation
Clarity and Assembly of Wiring Diagram	4.58	0.06	Excellent
Safety Considerations	4.56	0.07	Excellent
Functionality	4.59	0.03	Excellent
Demonstration Flow	4.60	0.06	Excellent
Visual and Interactive Elements	4.65	0.05	Excellent
Total Average	4.59	0.054	Excellent

4.2.1 Clarity and Assembly of Wiring Diagram

The evaluation of the demonstration model for wiring diagrams yielded highly favorable results, with all ten indicators rated "Excellent" and a grand mean of 4.58, reflecting strong consensus on its effectiveness as a teaching tool in electrical installation. The highest-rated indicator was spatial clarity in showing connector and wire placement (M = 4.68, SD = 0.76), emphasizing the model's strength in guiding accurate assembly. Accuracy and surety of wiring followed closely (M = 4.63), highlighting its role in teaching precision.

While the uniform excellence ratings affirm the model's educational value, they may also reflect a ceiling effect that limits sensitivity to areas for refinement. Future assessments could benefit from more nuanced scales and qualitative feedback to capture deeper insights. These

findings align with prior studies (e.g., Pereyras, 2020), affirming that the wiring demonstration model is clear, informative, and pedagogically effective.

4.2.2 Safety Consideration

The safety features of the demonstration model were rated highly, with a grand mean of 4.56, placing all indicators in the "Excellent" range. The highest-rated item was the presence of safety warning signs (M = 4.65, SD = 0.81), followed by the inclusion of a safety drawer for unused materials (M = 4.62), reflecting strong compliance with visual and procedural safety protocols.

Overall, the consistently excellent ratings confirm that the model is safe, reliable, and effective for instructional use. However, subtle areas for improvement remain, particularly in circuit installation practices and alignment with technical standards. These results reinforce earlier findings (Antonio, 2020), which likewise concluded that trainers are highly acceptable and effective with respect to safety considerations in educational contexts.

4.2.3 Functionality

Functionality assessment yielded a grand mean of 4.59, with all indicators rated "Excellent," confirming the demonstration model's effectiveness in supporting diverse wiring activities and fostering operational skills. The highest-rated item was its adaptability for both group and individual tasks (M = 4.64), underscoring its instructional flexibility. Several other items received equally high scores (M = 4.60–4.61), suggesting strong, consistent approval but also pointing to a potential ceiling effect, where the rating scale may not capture more nuanced feedback.

The lowest-rated feature, though still excellent, was the promotion of critical thinking (M = 4.53), indicating that while the model excels in practical training, it may be less effective in stimulating higher-order cognitive processes. The reported grand SD of 0.03 appears implausibly low compared to item-level variability, signaling a likely reporting or calculation error. Overall, the results affirm the model's strong functional capacity while highlighting opportunities to enhance its role in developing critical thinking skills, aligning with findings by Oguntunwase and Vincent (2021).

4.2.4 Demonstration Flow

Demonstration Flow reveal a grand mean of 4.60, indicating that the model provides a logical and effective learning sequence. The highest-rated feature was the discussion of the diagram's role in wiring activities (M = 4.67, SD = 0.76), which highlights its strength in bridging theory and practice. Lower, though still excellent, ratings were observed for explaining the objectives of the demonstration (M = 4.47, SD = 1.01) and demonstrating the wiring layout (M = 4.52, SD = 0.97), both showing higher variability and suggesting a need for clearer communication at the outset of instruction. Overall, the findings affirm the model's effectiveness in guiding structured learning while pointing to opportunities for improving clarity in initial explanations, aligning with Ezenwafor et al. (2020), who emphasized the value of demonstration and project-based teaching in enhancing students' psychomotor skills and interest in electrical installation.

4.2.5 Visual and Interactive Elements

The results on Visual and Interactive Elements show that this is the model's strongest aspect, with a grand mean of 4.65, underscoring its ability to engage learners and support intuitive understanding. The highest-rated indicator was providing learning mastery (M = 4.78, SD = 0.72), suggesting that the model greatly enhances retention and comprehension. Other high scores were

noted for engaging design (M = 4.68), structural appeal (M = 4.66), and interactive learning practices (M = 4.67), reflecting both visual strength and dynamic functionality in addressing diverse learning needs. Standard deviations ranging from 0.70 to 0.90 indicate moderate variability, possibly tied to differences in user familiarity with similar tools. Overall, the findings affirm that the model's visual and interactive features significantly contribute to competency development, echoing Ugot and Pasion (2023), who emphasized that well-designed instructional materials are essential in helping students build lasting understanding.

4.3 Level of acceptability

The figure further displays that the model is perceived as "Highly Acceptable" by the majority of participants. This reinforces earlier findings of strong consensus on clarity, safety, interactivity, and instructional value, affirming high acceptance across multiple evaluator groups.

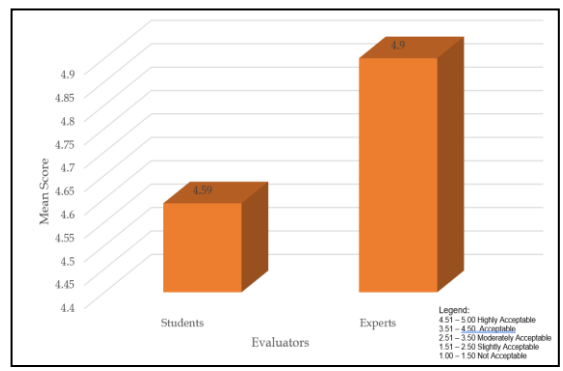

Figure 3. Level of Acceptability of the Developed Demonstration Model for Wiring a Four-Way Switch Control in Electrical Installation and Maintenance

5. Conclusion

The study concludes that the developed four-way switch wiring model is a technically sound and pedagogically valuable instructional tool. It was effectively designed to simulate real-world scenarios, allowing users to visualize and interact with actual wiring setups under safe and controlled conditions.

5.1 Design and development

The developed design model for wiring has proven to be both accurate and highly suitable for students' needs in electrical installation. Its user-friendly design and structure effectively captured the respondents' attention to detail, leading to approved satisfaction and agreement among them. Due to its white color, the model can easily get dirty and accumulate rust from tools. This may lead to stains and affect its surface condition, resulting in scratches and discoloration.

5.2 Evaluation of developed demonstration model

The model's evaluated objectives show that most respondents rated it as excellent, indicating a clear and positive experience. The wiring diagram within the model is comprehensive and intuitively structured, facilitating conceptual clarity and proper interpretation of electrical flows. The model embodies industry-standard safety measures, offering a safe environment for practice and learning, though minor variability in perceptions suggests continued emphasis on reinforcing installation safety. It supports a wide range of practical applications, from simple exercises to complex configurations, and encourages both skill mastery and critical thinking. The instructional sequence was perceived as logically ordered and pedagogically effective, ensuring that learners understand the rationale behind each step. The model demonstrates high visual engagement and hands-on functionality, enhancing learner motivation, confidence, and retention.

5.3 Level of acceptability

In this section both experts and students rated the model as highly acceptable, affirming its usability, effectiveness, and relevance in technical education. This conclude that the demonstration model for wiring meets the user needs, safety standard and functional requirements. However, experts were significantly more favorable, suggesting that the model aligns closely with professional standards and competencies.

6. Recommendations

- Enhance the interactive safety briefings within the demonstration flow to ensure consistent understanding of circuit wiring protocols.
- Include modular upgrades, such as integration with smart home components or programmable logic controllers (PLCs), to align with emerging trends in electrical systems.
- Develop a pre-use safety checklist to accompany the model, especially targeting less experienced users like high school students.
- Leverage the model to Junior and senior high school students to promote collaborative learning and problem-solving activities, maximizing its versatility in group or individual tasks.
- Promote adoption in technical institutions and senior high school EIM (Electrical Installation and Maintenance) program, supported by professional development for teachers.

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8. References

Antonio, W. D. (2020). Development and acceptability of multi-purpose electrical circuit demonstration trainer. International Journal of Advanced Trends in Computer Science and Engineering, 9(1.3), 208–214. https://doi.org/10.30534/ijatcse/2020/3191.32020

Bernaldez, R. R. (2015). Development of a prototype training device in electrical installation and maintenance: Equipping electrical technology students for Philippine National Competency Assessment. IAMURE International Journal of Mathematics, Engineering and Technology, 11(1). http://ejournals.ph/form/cite.php?id=2859

Ezenwafor, E. C., Okeke, B. C., & Oluka, C. N. (2020). Relative effectiveness of demonstration and project-based teaching methods in developing students' psychomotor skill and interest in electrical installation and maintenance work. The International Journal of Science & Technoledge, 8(1). https://doi.org/10.24940/theijst/2020/v8/i1/st2001-009

Kondakciu, K. (2020). Technology's impact on education – The Philippines. Yours Humanly. https://yourshumanly.org/technologys-impact-education-philippines/

Limpangog, M. A. (2024). Level of competency in electrical installation and maintenance to the academic performance among students. Psychology and Education: A Multidisciplinary Journal, 18(2). https://doi.org/10.5281/zenodo.10867058

Matos, A. (2024). Reasons proper wiring is essential for efficient electrical systems. ACT Electric. https://www.actelectricians.com/blog/reasons-proper-wiring-is-essential-for-efficient-electrical

Mazzarella, F., & Peruccio, P. P. (2013). Self-production: A human-centered design process. The sustainable future of self-production through a humanistic and participatory process. In D. De Moraes, R. A. Dias, & R. B. C. Sales (Eds.), Diversity: Design/Humanities. Proceedings of Fourth International Forum of Design as a Process (pp. 266–276). EdUEMG. ISBN: 978-85-62578-33-5

Oguntunwase, A., & Vincent, A. (2021). Design and development of a conduit wiring demonstration board for teaching and learning of electrical wiring skills in technical colleges. ResearchGate. https://www.researchgate.net/publication/365184974_Design_and_Development_of_a_Conduit_Wiring_Demonstration_Board_for_Teaching_and_Learning_of_Electrical_Wiring_Skills_in_Technical_Colleges

Pereyras, J. G. (2020). Development of an electrical wiring installation trainer. International Journal of Scientific and Technology Research, 9(3), 4458–4461.

Rosales, V. (2022). Acceptability of electrical installation and maintenance instructional trainer. Asia Research Network Journal of Education, 2(2), 84–101.

Saini, N. (2025). Produce more, buy less. Medium. https://medium.com/@23saini/produce-more-buy-less-63188637da99

Uduak, J. U., & Onwiodukit, F. A. (2019). Guided-discovery, demonstration methods and physics students' acquisitions of entrepreneurial skills in household electrical circuit sketch and wiring in Akwa Ibom State. [Conference paper or article, no journal details available].

Ugot, T. J., & Pasion, B. J. (2023). Design and development of AC/DC electrical installation and maintenance (EIM) trainer. The Quest: Journal of Multidisciplinary Research and Development, 2(3).

Weaver, A. (2015). The effect of a model demonstration during debriefing on students' clinical judgment, self-confidence, and satisfaction during a simulated learning experience. Clinical Simulation in Nursing, 11(1), 20–26.

Zacharia, Z. C., & de Jong, T. (2014). The effects on students' conceptual understanding of electric circuits of introducing virtual manipulatives within a physical manipulatives-oriented curriculum. Cognition and Instruction, 32(2), 101–158. https://doi.org/10.1080/07370008.2014.887083