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Vehicular Signal Circuit Trainer

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ABSTRACT

The study focused on the design and fabrication of a Vehicular Signal Circuit Trainer to serve as an instructional device for automotive technology students at Palompon Institute of Technology. The trainer was developed to provide a hands-on, interactive platform for learning the principles, operation, wiring installation, and troubleshooting of automotive turn signal and hazard lighting systems. Fault simulation tests demonstrated that the trainer reliably replicated common system failures, including blown fuses, broken wires, loose contacts, corroded terminals, short circuits, component failures, and low battery voltage. Evaluation by five instructors and thirty-eight students assessed design, performance, and safety using a structured five-point Likert scale. Results indicated high acceptability across all dimensions, with design receiving the highest mean score (4.76), followed by performance (4.73) and safety (4.70), yielding an overall grand mean of 4.74. Participants consistently rated the trainer as effective, reliable, and safe, confirming its suitability as a classroom demonstration and practical laboratory teaching tool. These findings suggest that the trainer system enhances student competence, supports instructional innovation, and provides a robust platform for experiential learning in vehicular signaling systems.

INTRODUCTION

Automotive electricity remains a fundamental component of automotive technology education, yet modern vehicle electrical systems have grown increasingly complex, presenting challenges for students in fully understanding the principles and operations of these systems. A solid grasp of fundamental electrical concepts is essential for appreciating advancements in automotive electronics and differentiating between conventional and modern technologies (Denton, 2017). Instructional trainers have proven effective in reinforcing these principles, providing students with structured, hands-on learning opportunities that enhance comprehension and practical skills. Despite their recognized value, access to well-designed instructional devices remains limited, prompting educators to develop innovative training models (Erjavec, 2015).

Recent studies indicate that hands-on tasks in vocational education improve technical proficiency and learning outcomes. For instance, instructional trainers implemented at the Palompon Institute of Technology were found to be highly acceptable and effective in terms of design, adaptability, safety, and efficiency, significantly enhancing student performance (Baldos & Chavez, 2025). Similarly, practical simulation tasks in automotive and refrigeration systems strengthen students' diagnostic understanding and skill acquisition (Ahmad *et al.*, 2015; Tarigan & Politeknik Astra, 2025; Baldos & Sabang, 2025; Chen, Hu, & Lin, 2025; Quispe-Astorga, Coaquira-Castillo, & Utrilla Mego, 2025).

In response to these instructional needs, the present study proposes the design and fabrication of an Vehicular Signal Circuit Trainer. The device is intended to provide a comprehensive, user-friendly platform for learning the principles, operation, wiring installation, and troubleshooting of automotive turn signal and hazard lighting systems. By enhancing laboratory resources, the Vehicular Signal Circuit Trainer aims to foster instructional innovation, strengthen student competence.

Objectives of the Study

The purpose of this study was to design and fabricate a prototype Vehicular Signal Circuit Trainer as an instructional device. Specifically, the study aimed to:

- Simulate device operation for fault detection and demonstration purposes.
- Evaluate the device in terms of design, performance, and safety.

MATERIALS AND METHODS

This study aimed to design and fabricate a prototype Vehicular Signal Circuit Trainer to address the need for instructional devices in the automotive technology laboratory at Palompon Institute of Technology. The project involved developing the trainer, simulating its operation as a fault detection tool, and evaluating its acceptability in terms of design, performance, and safety. The trainer was constructed with a casing and frame, terminal panel board, simulator panel board, and test cable lead case. Electrical components were wired according to the schematic design to ensure proper functionality. Fabrication involved assembling these components into a stable, operational unit ready for testing and demonstration (Figure 1, and 2).

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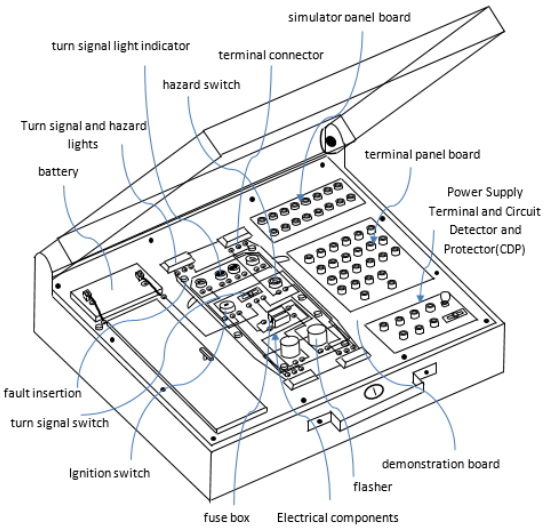

Figure 1: Vehicular Signal Circuit Trainer

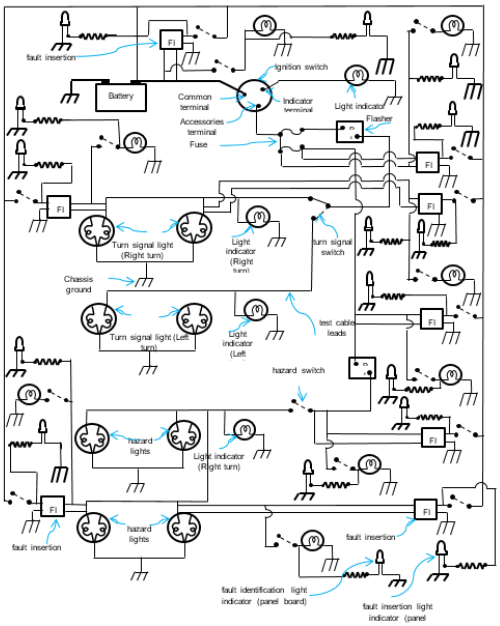

Figure 2: Trainer circuit diagram

Evaluation of the Project

The evaluation of the Vehicular Signal Circuit Trainer included both preliminary and final assessments to determine its functionality and acceptability in terms of design, performance, and safety. Upon completion of fabrication, the trainer underwent visual inspection and functional testing to ensure proper wiring connections, stable structural assembly, and adherence to the schematic design.

Minor modifications were carried out to ensure the device's full operational functionality of the trainer. For the final evaluation, a total of forty-three (43) respondents participated in the assessment of the trainer, consisting five teachers represents as experts and thirty-eight Automotive Technology students from PIT were selected based on their knowledge and familiarity with the subject matter. Following this, the participants evaluated the trainer using a structured five-point Likert scale adapted from established evaluation frameworks.

RESULTS AND DISCUSSION

The final evaluation of the Vehicular Signal Circuit Trainer involved five instructors and thirty-eight students of automotive technology at PIT, who assessed the device on fault simulation, design, performance, and safety.

Fault Simulation Test

The simulation of common faults in the signaling system showed consistent results between faculty and students across eight typical fault scenarios, including blown fuses, broken wires, loose contacts, corroded terminals, short circuits, component failures, and low battery voltage (Table 1). Minor variations in voltage and resistance readings were observed, attributed to the use of an analog

Table 1: Fault Simulation Test

Failure No.	Fault Description	Test Result (Faculty)	Test Result (Students)	Probable Cause
1	Turn signal (left & right) & hazard lights not working	✓	✓	Blown main fuse
2	Turn signal (right) not working	✓	✓	Broken wire connection
3	Hazard lights not working	✓	✓	Loose terminal connector
4	Turn signal (left) not working	✓	✓	Corroded terminal connector
5	Hazard lights not working	✓	✓	Short circuit in wiring
6	Turn signal (left & right) not working	✓	✓	Component failure (flasher)
7	Main indicator light not working	✗	✗	High resistance in wire
8	Turn signal (left & right) & hazard lights not working	✗	✗	Low battery voltage

multimeter. Overall, the results confirmed the trainer's functional accuracy and reliability in simulating faults in turn signal and hazard lighting systems.

Design Evaluation

Table 2 summarizes the participants' assessment of the trainer's design. Weighted mean scores ranged from 4.65 to 4.8, with an overall mean of 4.76, interpreted as "very acceptable." The highest-rated aspects were the construction and appearance of the electrical components and terminal/simulator panel boards, while the lowest-rated was the casing and frame. The low standard deviation (0.1) indicates strong agreement between students and instructors regarding the device's design, appearance, and workmanship.

Table 2: Design Evaluation by Students and Instructors

Design Criteria	Students Mean	Instructors Mean	Weighted Mean	Standard Deviation	Interpretation
Construction and appearance of casing and frame	4.6	4.7	4.65	0.05	Very Acceptable
Construction and appearance of electrical components	5.0	4.6	4.8	0.20	Very Acceptable
Construction and appearance of terminal and simulator panel board	5.0	4.6	4.8	0.20	Very Acceptable
Layout of parts and compactness of the device	4.8	4.7	4.75	0.05	Very Acceptable
Overall appearance and workmanship	4.8	4.8	4.8	0.00	Very Acceptable
Average/Overall	4.84	4.68	4.76	0.10	Very Acceptable

Performance Evaluation

As shown in Table 3, performance ratings for the trainer ranged from 4.65 to 4.8, with an overall mean of 4.73, described as "excellent." Highest scores were obtained for the effective functioning of turn signal and hazard lights. Slightly lower scores were assigned to the simulator panel board and combined device functions, though still within the "excellent" range. The low standard deviation (0.03) reflects consistent assessments across evaluators, indicating the trainer's operational effectiveness.

Table 3: Performance Evaluation by Students and Instructors

Performance Criteria	Students Mean	Instructors Mean	Weighted Mean	Standard Deviation	Interpretation
Effective turn signal lights function	4.8	4.8	4.8	0.00	Excellent
Effective hazard lights function	4.8	4.8	4.8	0.00	Excellent
Effective terminal panel board function	4.7	4.8	4.75	0.05	Excellent
Effective simulator panel board function	4.7	4.6	4.65	0.05	Excellent
Effective combined electrical devices function	4.7	4.6	4.65	0.05	Excellent
Average/Overall	4.74	4.72	4.73	0.03	Excellent

Safety Evaluation

Table 4 presents safety ratings, with weighted means ranging from 4.4 to 4.9 and an overall mean of 4.7, interpreted as "very safe." The use of wiring protective insulation achieved the highest rating, whereas portability received the lowest rating. Overall, participants agreed that the trainer's design incorporates appropriate safety features, including protective devices, accessible controls, secure wiring setup, and insulation, with low variance among raters (SD = 0.01).

Table 4: Safety Evaluation by Students and Instructors

Safety Criteria	Students Mean	Instructors Mean	Weighted Mean	Standard Deviation	Interpretation
Use of protective devices and circuit protectors	4.8	4.8	4.8	0.00	Very Safe
Accessibility of control switches	4.6	4.6	4.6	0.00	Very Safe
Mounting and setup of wiring board	4.6	5.0	4.8	0.20	Very Safe
Portability of the trainer device	4.6	4.2	4.4	0.20	Very Safe
Use of wiring protective insulation	4.8	5.0	4.9	0.10	Very Safe
Average/Overall	4.68	4.72	4.70	0.10	Very Safe

CONCLUSION

The study successfully designed and fabricated the Vehicular Signal Circuit Trainer as a functional instructional device for automotive technology students. Fault simulation tests demonstrated that the trainer reliably replicates common signaling system failures, confirming its effectiveness for practical teaching. The aggregate evaluation across design, performance, and safety yielded a grand mean of 4.74, with design receiving the highest score (4.76), followed by performance (4.73) and safety (4.70), indicating high acceptability. Both students and instructors consistently rated the trainer as an effective, reliable, and safe instructional tool. These findings suggest that the trainer system provides a hands-on, interactive platform that enhances students' understanding of turn signal and hazard lighting systems, wiring installation, and troubleshooting, and is highly suitable for classroom demonstration and practical laboratory training in vehicular signal circuit trainer.

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