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(REVIEW ARTICLE)

Development of a Customized Automotive-Electrical Trainer for Automotive Students at Samar State University

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Abstract

This study designed, developed, and evaluated a Customized Automotive-Electrical Trainer (CAET) for BSIT Automotive students at Samar State University. The trainer replicated essential automotive subsystems lighting, ignition, and charging circuits using locally sourced materials in a modular, safe, and flexible design. Fifteen students and three faculty evaluators assessed its functionality, usability, safety, and instructional effectiveness through Likert-scale instruments, observations, and interviews. Results indicated high performance across all criteria (overall weighted mean = 4.85, Excellent), with students reporting improved confidence in diagnosing faults and interpreting circuits. The CAET offers a cost-effective, hands-on instructional tool that bridges theoretical knowledge and practical skills.

Keywords: Automotive-Electrical Trainer; Technical-Vocational Education; Experiential Learning; Hands-On Learning; Fault Diagnosis; Modular Trainer; Electrical Circuits; Instructional Effectiveness

1. Introduction

Technical-vocational education and training (TVET) play a vital role in developing a skilled workforce capable of meeting the demands of modern industries. In the automotive sector, where technologies are rapidly advancing through the integration of electronics, automation, and diagnostic systems, the need for effective instructional tools has become increasingly critical. Automotive-electrical systems—encompassing lighting, charging, and ignition circuits—require both theoretical understanding and practical proficiency. However, many TVET institutions, particularly in developing regions, face recurring challenges such as limited access to functional training vehicles, costly diagnostic equipment, and safety concerns associated with live electrical systems. These limitations restrict students' opportunities for experiential learning, thereby hindering the development of essential technical competencies.

To address these instructional challenges, the use of simulation and trainer-based systems has gained significant attention in recent years. Trainer systems replicate real-world automotive subsystems in a controlled and safe environment, allowing learners to conduct experiments, observe system behavior, and diagnose faults without risking damage to vehicles or components. This approach aligns with Kolb's (1984) experiential learning theory, which emphasizes that knowledge is constructed through concrete experience, reflection, and active experimentation. Similarly, Lave and Wenger's (1991) concept of situated learning underscores the importance of authentic engagement within practice communities as a foundation for skill mastery. Both frameworks support the pedagogical rationale for using instructional trainers in technical education, where learning through doing remains central to professional development.

Empirical evidence supports the effectiveness of such instructional innovations. Baldos and Sabang (2025) developed a Fault Simulator for Refrigeration System Diagnostics, demonstrating significant improvements in students' diagnostic

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accuracy, engagement, and comprehension when exposed to controlled fault scenarios. Likewise, Baldos and Chavez (2025) designed a Lighting System and Airconditioning Instructional Trainer for automotive technology students, showing notable gains in learning efficiency, practical performance, and conceptual understanding. These locally developed instructional trainers illustrate how contextually designed, resource-efficient systems can effectively bridge the gap between theoretical instruction and industrial practice.

From a cognitive perspective, Seller's (1988) cognitive load theory reinforces the importance of instructional design that minimizes unnecessary complexity and supports effective learning. Trainer systems, by visualizing current flow and system interactions, reduce extraneous cognitive load and allow learners to focus on understanding functional relationships within electrical circuits. Furthermore, Braun and Clarke (2006) highlight that structured experiential and thematic learning environments foster greater motivation, engagement, and self-efficacy among learners—key factors for success in technical-vocational programs.

Despite these advancements, gaps remain in the literature. Most existing trainer designs focus on isolated systems or rely on imported components that are costly and difficult to maintain. Moreover, few studies have systematically documented the design, development, and evaluation of comprehensive automotive-electrical trainers aligned with local curricula and validated by both instructors and students. In the Philippine context, there is a particular need for modular, locally fabricated trainers that integrate multiple electrical subsystems while remaining affordable, durable, and pedagogically effective.

This study addresses these gaps through the design, development, and evaluation of a Customized Automotive-Electrical Trainer (CAET) specifically tailored for Bachelor of Science in Industrial Technology (BSIT) Automotive students at Samar State University. Building on the successful instructional frameworks of prior trainer systems (Baldos and Sabang, 2025; Baldos and Chavez, 2025) and grounded in experiential and cognitive learning theories, the CAET aims to:

- Replicate key automotive-electrical subsystems using locally available and maintainable components;
- Enhance conceptual understanding and reduce cognitive load through clear labeling, modular schematics, and structured experimentation; and
- Validate instructional effectiveness, usability, and acceptability through evaluation by students, and faculty.

2. Methodology

The study utilized a developmental–descriptive design integrating design, fabrication, and evaluation processes. The developmental phase focused on creating a Customized Automotive-Electrical Trainer (CAET), while the descriptive phase assessed its functionality, usability, and instructional effectiveness among students and experts.

Following the Design–Development–Evaluation (DDE) framework, the design phase identified key automotive electrical components, prepared circuit diagrams, and ensured safety and accessibility in layout planning. The development phase involved constructing the trainer with locally available materials, incorporating a 12-volt power supply, ignition switch, relays, fuses, and lighting circuits to simulate real vehicle systems. The evaluation phase assessed the trainer's performance through expert validation and student testing.

Participants included 15 BSIT Automotive students and three faculty evaluators selected through purposive sampling. Two instruments were used: a 5-point Likert evaluation checklist to assess functionality and usability, and observation and interview protocols to gather qualitative feedback. Quantitative data were analyzed using weighted mean and standard deviation findings from both analyses provided a comprehensive assessment of the trainer's educational value and practical effectiveness.

3. Design and Construction of the Trainer System

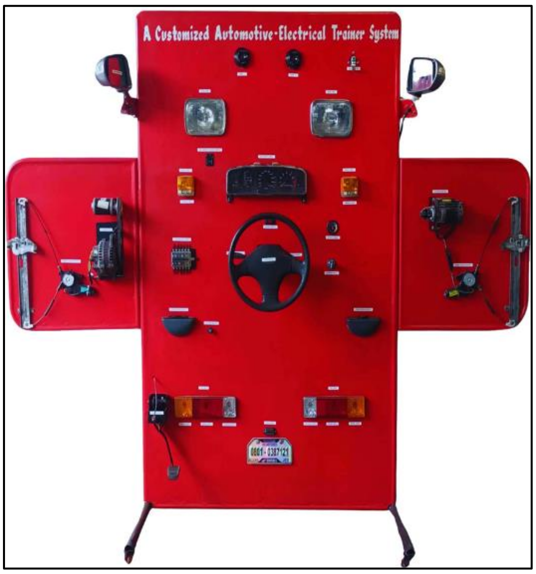

Figure 1 The Fabricated Customize Automotive Trainer System

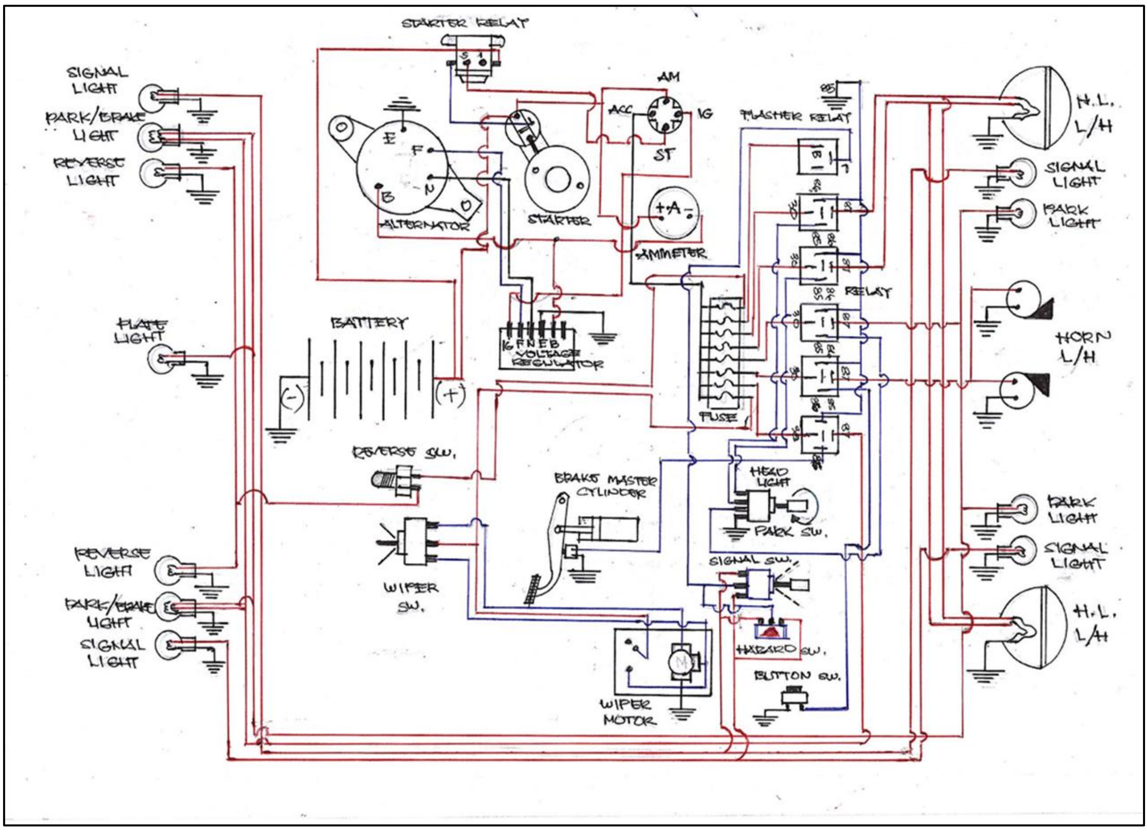

Figure 2 Schematic Wiring Diagram

The customized automotive-electrical trainer system was successfully designed and fabricated using locally sourced materials (figure 1). The setup replicated fundamental automotive circuits, including lighting, ignition, and charging systems, allowing students to visualize current flow, diagnose faults, and apply repair procedures in a controlled environment (figure 2). Its modular design provided instructional flexibility, enabling instructors to isolate specific circuits for demonstration or troubleshooting exercises. This approach facilitated focused, hands-on learning while ensuring adaptability for diverse instructional needs.

4. Evaluation of Functionality and Usability

The functionality and usability of the trainer system were assessed by both instructors and students, with results summarized in Table 1. The overall weighted mean of 4.85, interpreted as Excellent, indicates that the system effectively met its intended design objectives. Students reported ease of operation, while instructors highlighted the system's reliability, safety, and instructional value.

Table 1 Summary of Functionality and Usability Ratings

Criteria	Weighted Mean	Interpretation
Functionality	4.90	Excellent
Usability	4.80	Excellent
Safety	4.83	Excellent
Instructional Effectiveness	4.87	Excellent
Overall Mean	4.85	Excellent

These findings suggest that the trainer system performed highly across all evaluated parameters. The results reinforce the notion that well-designed, hands-on instructional tools enhance learner engagement, understanding, and motivation in technical education.

4.1. Instructional Impact

The integration of the automotive-electrical trainer into laboratory sessions positively influenced student participation and comprehension of electrical circuit concepts. Students reported increased confidence in identifying electrical faults, measuring voltages, and interpreting circuit diagrams. These outcomes are consistent with Kolb's (1984) experiential learning theory, which emphasizes concrete experience and active experimentation as critical components of skill acquisition.

Instructors observed that the trainer reduced the need for repeated demonstrations, allowing students to work independently and promoting self-paced, inquiry-based learning. The trainer system demonstrates effectiveness as a practical and pedagogically sound learning resource for technical-vocational education.

5. Conclusion

The study successfully designed, developed, and evaluated a Customized Automotive-Electrical Trainer (CAET) for BSIT Automotive students, replicating key subsystems such as lighting, ignition, and charging circuits using locally sourced materials. Evaluation by students and faculty indicated high functionality, usability, safety, and instructional effectiveness (overall weighted mean = 4.85). Integration of the trainer into laboratory sessions enhanced student engagement, confidence, and comprehension in diagnosing and troubleshooting electrical circuits, supporting experiential and inquiry-based learning.

The modular, hands-on design allowed independent practice while reducing repetitive demonstrations, demonstrating both pedagogical and practical value. The CAET provides a cost-effective, durable, and contextually relevant model for technical-vocational education, bridging theoretical knowledge and practical skills. Future developments may expand its functionality to additional automotive subsystems, further enhancing workforce readiness and technical competence.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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