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Development of a Motorcycle Charging System Trainer as a Student-Centered Learning Medium for Vocational Automotive Education

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Abstract

The Indonesian government prioritizes vocational education as a human resource development strategy to meet industrial needs. This study developed a Trainer for the Motorcycle Charging System at the PVTO Laboratory of PGRI University Yogyakarta using the ADDIE model. The Design phase utilized Autodesk Fusion 360 to design an ergonomic hollow steel frame, while the Development phase included frame fabrication, installation of a standard wiring system, and integration of digital measuring instruments for real-time visualization of electrical parameters. Technical testing results showed 100% system functionality and very high physical feasibility with a validation score of 4.71/5.00. This product has proven effective as a troubleshooting tool that facilitates systematic diagnosis and supports students' mastery of mechanical competencies.

Keywords: Charging System Trainer; Troubleshooting; Vocational Learning Media; Automotive Education; ADDIE Model

Abstrak

Pemerintah Indonesia memprioritaskan pendidikan vokasi sebagai strategi pengembangan sumber daya manusia untuk memenuhi kebutuhan industri. Penelitian ini mengembangkan alat peraga (trainer) sistem pengisian daya sepeda motor di Laboratorium PVTO Universitas PGRI Yogyakarta dengan menggunakan model ADDIE. Tahap perancangan menggunakan Autodesk Fusion 360 untuk mendesain rangka baja berongga yang ergonomis, sedangkan tahap pengembangan mencakup fabrikasi rangka, pemasangan sistem kelistrikan standar, dan integrasi alat ukur digital untuk visualisasi parameter kelistrikan secara real-time. Hasil pengujian teknis menunjukkan fungsionalitas sistem sebesar 100% dan kelayakan fisik yang sangat tinggi dengan skor validasi 4,71/5,00. Produk ini terbukti efektif sebagai sarana pemecahan masalah yang memfasilitasi diagnosis secara sistematis serta mendukung penguasaan kompetensi mekanik bagi mahasiswa.

Kata-kata kunci: *Trainer Sistem Pengisian; Pemecahan Masalah; Media Pembelajaran Vokasi; Pendidikan Otomotif; Model ADDIE*

1. Introduction

The rapid advancement of automotive technology in the era of the 5.0 Industrial Revolution demands significant adaptation in the vocational education sector, particularly in the mastery of electrical systems, which form the foundation of electric vehicle technology [1]. However, laboratory observations indicate that the practical learning process is still hampered by the inefficient use of complete motorcycle units (built-up units). The use of complete units causes the charging system components and wiring harnesses to be obscured by the vehicle's body, resulting in practical training time being spent on mechanical disassembly rather than technical diagnosis (troubleshooting) [2].

The lack of representative practical resources has a direct impact on students' limited technical ability to systematically analyze the workflow of the refueling system [3]. We need a training aid in the form of a Motorcycle Charging System Trainer with an open-layout design that clearly visualizes the current flow from the stator, through the regulator, to the battery [4]Media trainers should be designed to facilitate inquiry-based learning so that students can perform hands-on experiments and independently track interference [4].

A motorcycle charging system is a vital electrical subsystem that generates electrical energy through electromagnetic induction to power electrical components while maintaining optimal battery capacity [5] & [6] The efficiency of a charging system is determined by three main components, namely :

a. Alternator

The alternator (coil) serves as the primary source of alternating current (AC) electrical energy by utilizing the principle of electromagnetic induction generated by the rotation of the engine's crankshaft [7].

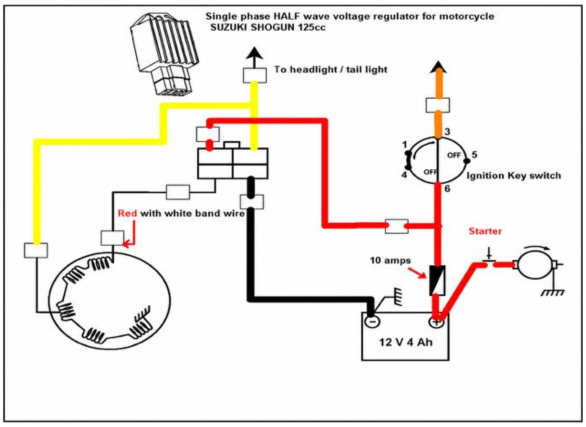

Figure 1. Schematic Diagram of a Half-Wave Charging System

Based on **Figure 1**, this diagram shows the electrical schematic of a half-wave charging system for a motorcycle, illustrating the flow of current from the alternator to the regulator, the headlight, and the battery as the main power source.

b. Regulator

The regulator/rectifier (Kiprok) plays a vital role in converting the AC current from the alternator into direct current (DC) while also controlling the charging voltage to ensure it does not exceed the battery's maximum threshold.

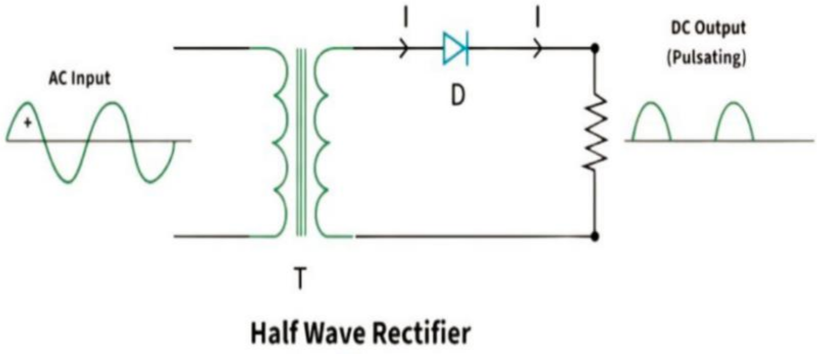

Figure 2. Regulator /Rectifier

As shown in Figure 2, this technical diagram illustrates a half-wave rectifier circuit that uses diodes to convert the AC current at the input into pulsating DC current at the output, which is the basic operating principle of the charging system.

c. Battery

The battery serves as a storage unit for electrical energy in the form of chemical energy, supplying power to the vehicle's entire electrical system when the alternator is not operating at full capacity.

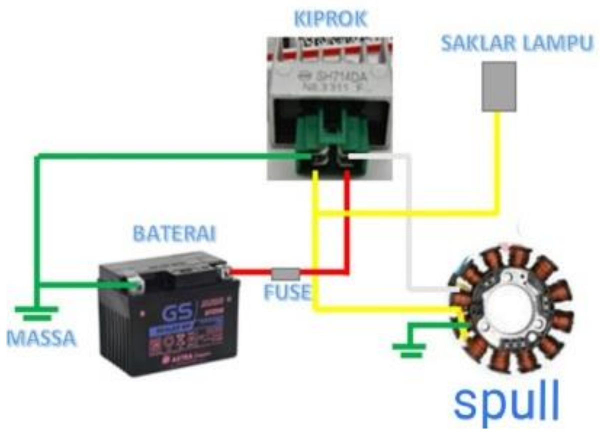

Figure 3. Honda Absolute Revo Charging Circuit Diagram

As shown in Figure 3, this wiring diagram illustrates the charging system circuit of the Honda Absolute Revo, which includes key components such as the regulator, battery, fuse, headlight switch, and stator.

The development of this training material follows the ADDIE instructional model (Analysis, Design, Development, Implementation, Evaluation) because this framework is highly systematic for producing technically validated products [8]. During the design phase, the product blueprint is developed with consideration for the ergonomic dimensions of the hollow steel frame and the determination of test measurement points (checkpoints) to facilitate electrical diagnostics. The integration of digital measuring instruments into the trainer's instrument panel is crucial for providing instant feedback on the performance of the charging system.

The Development phase focuses on the physical fabrication of the trainer, which includes assembling key components such as the alternator, regulator, and battery, along with installing the wiring system in accordance with technical standards [9]. A sturdy mechanical structure and neat cable installation are key standards for workplace safety in the laboratory [10]. The use of modern semiconductor components in the trainer regulator also helps prevent overcharging, which can damage the battery during simulations. Technically, the open-layout design increases practical training efficiency by up to 40% by eliminating the time spent disassembling irrelevant vehicle components [11]. Through R&D, this trainer has successfully become a valid diagnostic tool for charging systems and an effective solution for improving the quality of hands-on learning in the laboratory.

2. Method

This study used the ADDIE model to address the challenges of laboratory experiments through three systematic phases: needs analysis, technical design based on Autodesk Fusion 360, and the development of a physical product in the form of an electrical trainer with a real-time digital measurement system [12].

The Implementation and Evaluation phase includes field testing and a comprehensive evaluation of product quality [13]. Validation tests were conducted by subject matter experts and media specialists to assess the appropriateness of the content [14], occupational safety and health (OSH) aspects, and the pedagogical value of the instructional media. Data analysis was performed using quantitative descriptive methods the mean formula ($x = (\sum X)/N$) to measure the level of suitability, as well as qualitative analysis of validators' feedback to ensure the product's technical standards and pedagogical effectiveness prior to implementation.

The object of this research was the Motorcycle Charging System Trainer developed for practical learning purposes, while the research subjects consisted of one content/subject matter expert and one media expert who served as validators, in addition to students of the Vocational Education in Automotive Technology study program at PGRI University of Yogyakarta who used the trainer during the Implementation phase at the PVTO Laboratory.

Data were collected using a closed validation questionnaire (instrument sheet) employing a five-point Likert scale (1–5), which was distributed to the content expert and media expert. The content expert questionnaire covered three indicators: content appropriateness, learning support specifications, and the concept of truth, while the media expert questionnaire covered four indicators: appearance and design, technical aspects and functions, occupational safety and health (OSH) aspects, and pedagogical aspects and Student-Centered Learning (SCL). Supporting data were also obtained through direct observation during the technical functional testing of the trainer.

The validation scores from each expert were analyzed quantitatively using a descriptive percentage technique, with the feasibility percentage calculated using the formula: Percentage = (∑score obtained / ∑maximum score) × 100%. The resulting percentage was then interpreted using four feasibility categories: 0–25% (not feasible), 26–50% (less feasible), 51–75% (feasible), and 76–100% (very feasible). Qualitative input and suggestions from the validators were analyzed descriptively and used as the basis for product revision prior to the Implementation phase.

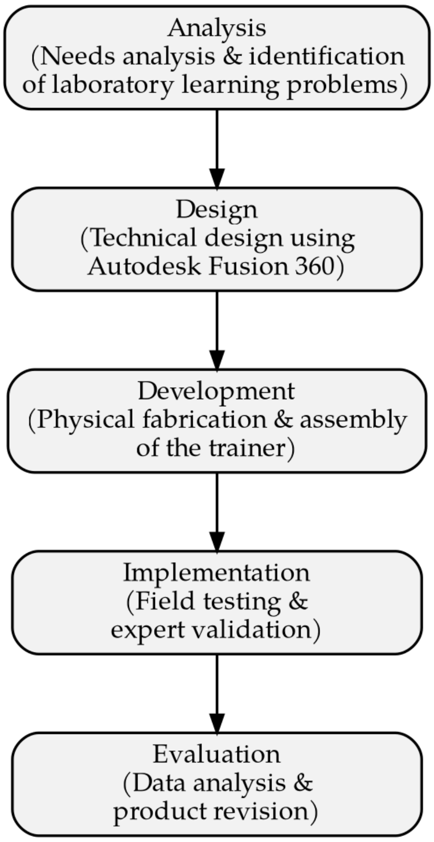

Figure 4. Flowchart of the ADDIE Research and Development Stages

3. Results and Discussion

This study employed an R&D approach using the ADDIE model to develop a Motorcycle Charging System Trainer as a Student-Centered Learning (SCL)-based instructional tool. This tool was specifically designed with troubleshooting features to integrate technical skills (hard skills) and pedagogical competencies among prospective vocational teachers at the UPY PVTO Laboratory. As a result, the ADDIE model proved effective in producing a functional learning tool, while the SCL approach through peer teaching successfully enhanced students' independence, critical thinking skills, and technical communication skills [15] & [16].

Results of the requirements analysis and design of the motorcycle charging system trainer unit :

3.1 Analysis (Analisis)

Needs assessment indicates that using a complete motorcycle as a teaching aid is less effective because its components are enclosed by the body [17], thereby hindering the efficiency of practical training and understanding of electrical circuits. In addition, a gap in pedagogical competence was identified, whereby students struggled to explain the concept of the charging system systematically during microteaching sessions. Therefore, the need was established for an open (visual) training aid that supports troubleshooting, facilitates Student-Centered Learning (SCL) [18], and meets laboratory safety standards.

3.2 Design

This training tool consists of a portable, ergonomic steel frame designed to integrate a charging system, an instrument panel, and test points. In addition to the physical equipment, the design includes instructional materials (SCL worksheets and an operational guide) to support students in teaching simulations and self-assessment, thereby aligning the development of technical hard skills with teaching skills.

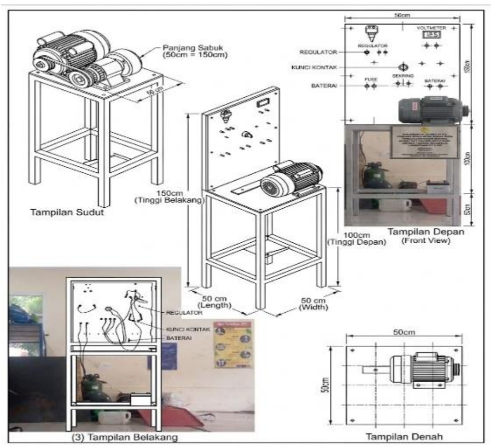

Figure 5. Design Trainer

Based on Figure 5, this design is a schematic diagram of the main frame of the training device, which is 150 cm high, 50 cm long, and 50 cm wide, and is designed to support the ergonomic placement of the charging system components. This design also ensures a sturdy, balanced, and efficient structure for component placement and supports the effectiveness of hands-on learning activities.

3.3 Development

This stage involves transforming the design into a physical product through the fabrication of the steel frame, the installation of acrylic instrument panels, the electrical installation, and the integration of charging system components and digital gauges. This process concludes with electrical functional testing to ensure that all technical specifications and workplace safety standards are met.

Based on **Figure 6**, this photograph depicts the fully assembled charging system trainer unit, complete with an instrument panel, major electrical components, and measurement units for diagnosing electrical faults.

Figure 6. Front view of the trainer

Based on **Figure 7**, this side-view illustration of the training unit shows the cable routing and placement of key components so that students can easily access and observe them during the lab session.

Figure 7. side view of the trainer

Based on **Figure 8**, this documentation the pedagogical method is implemented in the teaching aid.

Figure 8 : The Trainer Painting Process

3.4 Expert Validation

The results of the content expert validation showed an overall suitability rate of 93%, indicating that the developed learning content is suitable for use in the learning process. The results of the content expert validation assessment are presented in Table 1.

Tabel 1. Content Expert Validation Result

Asseement Items	Content Expert Validation		
	Aspects of Content Appropriateness	Learning Support Specifications	The Concept of Truth
1	4	4	4
2	4	5	5
3	5	5	5
4	5	5	5
5	4	5	5
Total	22	24	24

Feasibility Percentage= $\frac{70}{75} \times 100\%$ = 93%

Validation by content experts or subject matter experts yielded an overall suitability rate of 93%, indicating that the learning content is highly suitable for use. The results of the validation by media experts are presented in Table 2.

Tabel 2. Media Expert Validation Review

Asseement Items	Media Expret Validation			
	Appearance & Design	Technical aspects & functions	Occupational Safety and Health (OSH) Aspects	Pedagogical Aspects & SCL
1	5	5	5	5
2	5	5	4	4
3	4	5	5	5
4	4	5	5	4
5	5	5		4
				5
				5
Total	23	25	19	32

Feasibility Percentage= $\frac{99}{105} \times 100\%$ = 94%

This study successfully developed a Motorcycle Charging System Trainer based on the ADDIE instructional design model and the Student-Centered Learning (SCL) approach. The needs analysis identified limitations in using complete motorcycles as instructional media, particularly the difficulty in observing electrical components and students' limited pedagogical skills during teaching practice. The developed trainer features an open and ergonomic design that facilitates troubleshooting activities, hands-on learning, and peer teaching. Expert validation demonstrated that the trainer is highly feasible, with 93% content validity and 94% media validity, indicating that it is appropriate for vocational learning. The trainer effectively supports the integration of students' technical competencies (hard skills) and teaching competencies, while promoting independent learning, critical thinking, and communication skills.

4. Conclusion

This research and development study successfully developed a Motorcycle Charging System Trainer for the PVTO Laboratory at PGRI University Yogyakarta using the ADDIE model. The developed trainer integrates real automotive charging system components with a Student-Centered Learning (SCL) approach to support students' technical and pedagogical competencies. The validation results demonstrated that the product is highly feasible for learning implementation, obtaining 93% from the subject matter expert and 94% from the media expert. These findings indicate that the trainer is valid, functional, and appropriate for vocational laboratory practice. Therefore, the Motorcycle Charging System Trainer can be used as an effective and innovative instructional medium to improve troubleshooting skills, critical thinking, and practical competence among prospective vocational teachers.

Based on the results of expert validation, product testing, and learning evaluations, the motorcycle charging system trainer has been deemed highly suitable for use as a practical learning tool and effective in enhancing the pedagogical skills of vocational education students at PGRI University Yogyakarta. Thus, the development of this motorcycle charging system trainer can serve as an innovative alternative practical learning tool to support the enhancement of competencies among prospective automotive vocational teachers in the era of modern education.

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