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The fabrication of electric motorcycle trainers to eliminate automotive misconceptions

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ABSTRACT

This study aims to develop and implement learning media in the form of electric motorbike trainers to improve students' understanding of electric vehicle technology. The research method used is research and development (R&D) with the Successive Approximation Model (SAM) approach, which is applied in the electric vehicle technology course curriculum in the Automotive Engineering Education study programme. The participants in this study were undergraduate students involved in the learning process using an electric motorbike trainer. The research instruments included observation, interviews, questionnaires, and practical assessment sheets. The results showed that the designed electric motorbike trainer can be used properly and is feasible to operate in the learning process if used in accordance with procedures. Based on the assessment of material experts and media experts, this learning media is considered feasible to implement in learning. A survey of 47 students showed that 63% of respondents strongly agreed that this electric motorbike trainer is an effective innovation in supporting learning. In conclusion, the development of this electric motorbike trainer not only enriches the learning experience but also has the potential to improve students' understanding of electric vehicle technology. This research contributes to providing innovative learning media that is relevant to today's technological needs and can be adopted more widely in various technical education institutions.

INTRODUCTION

The escalation in greenhouse gas emissions stemming from internal combustion engines has fueled a surge in research on vehicle electrification. Electric vehicles (EVs) offer several key benefits, including reduced carbon monoxide (CO) emissions, enhanced efficiency, and reduced maintenance costs. This shift also drives the transition of energy sources for vehicle propulsion towards renewable energy sources (Poornesh et al., 2020). The transportation sector, responsible for approximately 50% of global oil consumption, significantly contributes to CO2 emissions (Aravena & Denny, 2021). Consequently, increasing the adoption of electric vehicles (EVs) emerges as a pivotal strategy to mitigate vehicle-related pollution and diversify the energy sources employed in transportation. Furthermore, electric vehicles (EVs) serve as a viable solution to address the scarcity of petroleum fuel for Internal Combustion Engine (ICE) vehicles (Ali et al., 2022).

Technical and Vocational Education and Training Institutions (TTIs) play a crucial role in shaping the future of the automotive industry by producing educators (teachers) who are instrumental in improving the quality of human resources in Indonesia (Rochmansjah, 2024). Given their significant contribution, it is imperative to prioritize the quality of teaching staff in these institutions. Equipping prospective teachers with the ability to master educational concepts, connect educational concepts, education and learning concepts, understand students, and emphasize problem-solving skills in education is a powerful step towards advancing vocational education in Indonesia (Angraini et al., 2016).

Electric vehicles (EVs) are a new thing in the world of education, so learning about electric vehicles has not been held in several educational institutions, one of which is at the Universitas Pendidikan Indonesia (UPI). Based on the interviews with lectures, the electric vehicle technology course in the automotive engineering education study program, faculty of technology and vocational education, UPI, there was no learning media for visualization and practicum. Therefore, for now, electric vehicles are still rarely known by students of the automotive engineering education study program. That caused a misconception among students of the automotive engineering education study program regarding electric vehicles.

Developing trainers is an adequate solution to reduce misconceptions in practical learning. These tools enable students to understand complex concepts through direct application, strengthening their theoretical comprehension and bridging the gap between theory and practice (Ulum et al., 2024). Additionally, trainers provide simulations of real-world scenarios, such as automotive diagnostic trainers for troubleshooting vehicle electrical systems, patient care simulators in medical education for developing clinical decision-making skills, and industrial automation trainers for programming and operating robotic arms, that enhance students' practical skills and offer a systematic approach to problem-solving and error simulation, which is crucial for developing critical thinking skills (Harper et al., 2024; Ulum et al., 2024). Trainer-based learning models have been proven effective in various fields, such as audio system training with a suitability rate of 92% according to experts and 88% according to students, as well as in healthcare through the train-the-trainer model, which improves knowledge dissemination and skill acquisition among nurses (Nexø et al., 2024). With trainers in place, practical sessions become more structured and guided, reducing errors in laboratory work and enhancing students' overall learning experience.

The Pyra Deployment Model (PDM) also plays a role in structuring systematic training activities, allowing trainers to effectively guide students in deeply understanding concepts (Duvivier et al., 2023). Therefore, the development of trainers is highly valuable in improving the effectiveness of practical learning. However, more comparative studies are needed to evaluate their impact on learning outcomes. It's important to note that the careful consideration of implementation complexities, such as resource allocation and training of trainers, is crucial to ensure optimal use of trainers (Duvivier et al., 2023; Nexø et al., 2024).

Demonstrating a Trainer tool represents a learning medium that embodies the typical characteristics of concepts students learn during the educational process (Sudjana, 2009). By utilizing Trainers, students are exposed to recalling and observing existing materials and engaged in the direct application and practical implementation of theories, thereby enhancing their understanding of the subject matter. According to Hasan (2006), Trainers are laboratory or workshop equipment designed as educational tools, combining working models and mock-ups. These Trainers are intended to support participants in applying the knowledge and concepts they have acquired to real-world objects. The mock-up model simplifies the arrangement of the main parts of a process or complex system. From this explanation, it can be inferred that Trainers serve as learning media in the form of simulated replicas or miniature models, aiding students in their practical activities in the laboratory or workshop. This, in turn, facilitates their comprehension and mastery of the presented theoretical concepts (Sonsang & Simeru, 2022).

In previous research on the use of trainers of wiper and washer simulators to improve understanding of light vehicle electricity for vocational high school students, learning outcomes using wiper and washer learning media in the light vehicle machine maintenance subject increased significantly (Santoso et al., 2019). Whereas in other studies regarding increasing understanding of basic computer network courses using the Cisco packet tracer network simulator, the learning process using the Cisco packet tracer network simulator has a positive impact in efforts to increase understanding of basic computer network theory for the informatics management study program (Martanto & Anwar, 2021).

The research of improving a pneumatic simulator media based on a dual design as a helping media for electro-pneumatic exercise has the extraordinary benefit of improving college student knowledge of electro-pneumatic circuits and components. Therefore, this simulator is predicted to allow students to deepen their knowledge efficiently, as there is no need to give high-priced, unique products to college students. This media simulator is the strategic answer for growing learning nearly equal to the unique, permitting you to get a better return on your investment in rate and time (Ramdani et al., 2020). Further research used the Richey and Klein's (2014) Design and Development (D&D) approach, which consists of three levels: making plans (design), manufacturing, and assessment. Specialists assessed the feasibility of the instructor kit with a tool in the shape of a questionnaire. The results of this look imply that the instructor package has a terrific performance (Anwar et al., 2021).

According to the research and development findings conducted on the learning media for the R32 split AC trainer package, which was accomplished using the Successive Approximation Model (SAM) method, several significant outcomes were observed. The evaluation of media expert eligibility resulted in a classification of "very feasible." Similarly, the assessment of feasibility by theorists also yielded a "very feasible" rating. Moreover, the eligibility test administered to 30 student respondents was categorized as "very appropriate." Furthermore, the performance training assessment of 10 students who engaged in teacher practicum and utilized job sheets garnered a "good" rating (Ningsih et al., 2021).

Based on previous research findings, instructional media has enhanced students' understanding of technical concepts. This aligns with the assertion by Sadiman et al. (2011) that effective classroom learning is significantly influenced by two key aspects: teaching methods and learning media. Learning media facilitate instruction by demonstrating specific processes, objects, or scenarios in real form or as simulations. However, despite the growing body of research on educational media, studies specifically focusing on implementing electric motorcycle trainer learning media to enhance students' understanding of electric vehicles remain limited. Previous research on electric vehicles primarily explores aspects such as production technology education and the application of lithium-ion batteries in electric vehicles (Dyartanti et al., 2021).

Other studies, such as Sagita (2020), have examined innovative approaches like the game "Project Electrorace" design as a medium for socializing electric vehicles, demonstrating the potential of gamification in promoting EV awareness among the public. Given this context, this research seeks to address the gap in the existing literature by developing and evaluating an electric motorcycle trainer as an instructional tool aimed at eliminating misconceptions about electric vehicle technology among students in automotive education programs. The primary objectives of this study are (1) to design and fabricate an electric motorcycle trainer for use in technical and vocational education, (2) to evaluate its feasibility and effectiveness as a learning tool, and (3) to measure its impact on students' conceptual understanding of electric motorcycles. The contribution of this research lies in providing an innovative and structured learning medium that supports practical, hands-on education in electric vehicle technology, thereby enhancing students' comprehension and readiness for the evolving automotive industry. Additionally, this study addresses an urgent need for modernized vocational education curricula that align with global trends in sustainable transportation and electric vehicle adoption.

METHOD

The research was conducted to develop practical learning media in the form of electric motorcycle trainers using the Successive Approximation Model (SAM) method. This approach was chosen due to its iterative and flexible nature, allowing continuous evaluation and refinement of the training media throughout development. The study was conducted in the Electric Vehicle Technology course in the automotive engineering education study program, faculty of technology and vocational education, Universitas Pendidikan Indonesia (UPI). Implementing this research is expected to significantly enhance students' understanding of electric vehicle systems, particularly in diagnosing and maintaining electric motorcycles, which are becoming increasingly relevant and impactful in the automotive industry.

The SAM model, with its structured phases of preparation, iterative design, and iterative development, served as a fundamental framework, ensuring that the electric motorcycle trainer was developed efficiently while addressing usability, effectiveness, and industry relevance. Unlike traditional linear models, SAM's unique feature of allowing ongoing feedback and rapid prototyping makes it highly suitable for educational product development, where real-time improvements are crucial. The first model of SAM, as shown in Figure 1, is particularly effective for research involving small-scale yet impactful innovations that require adaptability and repeated testing (Allen & Sites, 2012). By integrating SAM principles, this research aimed to bridge the gap between theoretical knowledge and hands-on learning, ensuring that students receive comprehensive and industry-aligned training in electric vehicle technology. The outcome of this study is expected to provide a sustainable and scalable learning tool that can be adopted in vocational and higher education institutions to support the growing transition towards electric mobility.

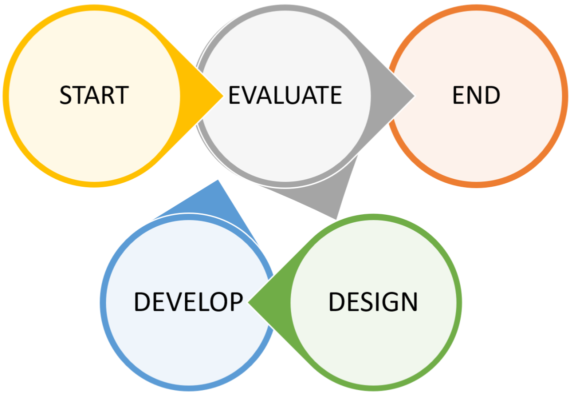

Figure 1. The stages of Successive Approximation Model (SAM)

This research, which involved 47 sixth-semester students, employed a comprehensive data collection process. This process included observations, interviews, questionnaires, and practice assessment sheets. The observations, conducted in the Automotive Engineering Education laboratory at Universitas Pendidikan Indonesia, assessed the availability of tools and components necessary for developing the electric motorcycle trainer. The results indicated that while some electric motorcycle components were available, additional supporting components were required.

Interviews were conducted with the head of the laboratory, a key collaborator in this research, to reinforce observations and identify key challenges in practical learning. The findings highlighted the need for learning media to support hands-on training, leading to the development of the electric motorcycle trainer as a practical learning tool.

To assess the feasibility and effectiveness of the trainer, questionnaires were distributed to media experts, content experts, and student respondents. The media expert questionnaire evaluated display, labeling, writing, and technical quality. The content expert questionnaire ensured alignment with the curriculum, instructional quality, and content relevance. The student feasibility questionnaire assessed usability and design aspects, providing a comprehensive evaluation of the trainer. Responses were measured using a Likert scale (Sugiyono, 2016), with validation criteria ranging from "Very Eligible with Revision" (81%-100%) to "Very Not Eligible with Revision" (0%-20%) (Khoiroh et al., 2019). The collected data were analyzed to determine the trainer's effectiveness in supporting practical learning and its potential improvements before implementation.

RESULTS AND DISCUSSION

Results

Our observations and interviews conducted in the Automotive Engineering Education Laboratory in September 2022 identified a significant shortage of trainers for the Electric Vehicle Technology Course and supporting materials such as job sheets and user manuals. This shortage hinders students' learning experiences and affects the quality of practical education. The learning objectives for this practical electric motorcycle technology training align with SKKNI 2021

(Indonesian National Work Competency Standards), ensuring that our training is relevant and up-to-date with industry standards. The initial stage of development involved designing the trainer structure to ensure optimal placement of key components, as depicted in Figure 2, which showcases the layout and design modeled using Autodesk Inventor.

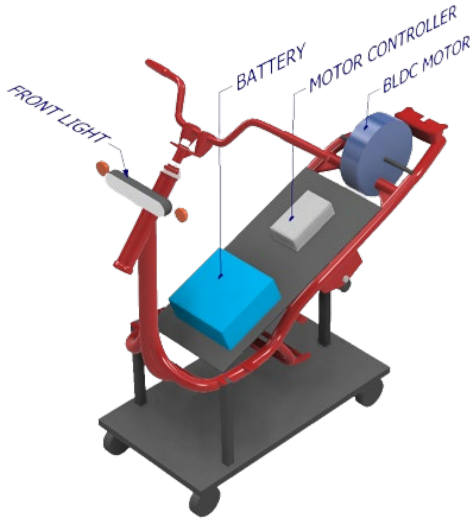

Figure 2. Design of Electric Motorcycle Trainer

After finalizing the trainer's design, the electric motorcycle components were carefully fabricated and assembled. The next step involved modifying the motorcycle frame, integrating a support frame for the caster wheel, and installing the core electrical components, including the Battery, Motor Controller, and BLDC Motor, as labeled in Figure 2. Each component underwent a rigorous testing phase to verify functionality and ensure its placement met the intended design specifications.

Following the installation process, we conducted several stages of testing to ensure the structural durability and electrical system reliability of the electric motorcycle trainer. The BLDC motor and electrical connections were rigorously tested to confirm proper operation, along with a strength test of the modified frame to assess whether it could support the trainer's mechanical and electrical systems. Additionally, a comprehensive series of trials was conducted using practicum job sheets, allowing students to interact with the trainer in real-world learning scenarios. These tests, which were designed to be as thorough as possible, ensured that the trainer meets industry standards and provides an effective learning tool for students in the Automotive Engineering Education Study Program.

The final assembly of the electric motorcycle trainer integrates all necessary components and is now fully prepared for educational use. Figure 3 presents the fully assembled electric motorcycle trainer, showcasing the completed structure with all functional elements in place. This readiness ensures that educators and students can immediately begin using the trainer for their learning and teaching needs.

With the aim of creating a practical learning tool, the electric motorcycle trainer was meticulously designed and its components fabricated. This paved the way for the assembly and comprehensive testing that followed, ensuring the trainer's functionality and effectiveness. The frame modifications were completed, integrating key electrical and mechanical components, including the Battery, Motor Controller, BLDC Motor, and Electronic Control System. The fully assembled trainer, as illustrated in Figure 3, represents the final version after structural reinforcement and the installation of all necessary wiring and control elements.

Once all components were installed, the trainer was subjected to rigorous testing procedures. The first testing stage, which was crucial in validating the correct flow of electricity and the integration of safety mechanisms, involved the electrical system. Each connection was examined to verify proper wiring continuity, power distribution, and controller response to throttle inputs. This stage was a key step in ensuring the system's overall reliability and feasibility.

Figure 3. The Assembly of Electric Motorcycle Trainer

Following this, the motor performance was evaluated by analyzing the BLDC motor's efficiency and torque output under different operational conditions. The rotational speed, power consumption, and heat dissipation were closely monitored to ensure that the motor operated within its optimal performance range. Any inconsistencies were addressed by adjusting the motor controller parameters and refining the electrical configuration.

The third phase of testing was a critical step in ensuring the trainer's structural integrity and its ability to withstand prolonged use. Since modifications were made to the motorcycle frame, it was essential to assess its ability to support all installed components without deformation. The frame underwent load-bearing assessments and stability tests, ensuring that it could withstand prolonged use in a practical learning environment.

Lastly, a user interaction trial was conducted, providing students with a valuable opportunity to engage with the trainer under controlled conditions. This involved operating the throttle and control systems, monitoring real-time performance feedback, and troubleshooting simulated faults. This phase aimed to assess the trainer's effectiveness as an educational tool, ensuring that it provided a realistic hands-on experience in electric vehicle technology.

Table 1. Summary of Testing Phases

Testing Phase	Description
Electrical System Testing	Evaluated wiring continuity, power distribution, and controller response to throttle inputs. Ensured proper electricity flow and safety mechanisms.
Motor Performance Testing	Assessed BLDC motor efficiency, torque output, rotational speed, and heat dissipation. Adjusted controller parameters for optimal performance.
Structural Integrity Testing	Examined frame durability, ensuring it could support all components without deformation. Conducted load-bearing assessments and stability tests.
User Interaction Trial	Students engaged in throttle operation, monitored real-time feedback, and performed troubleshooting exercises to enhance learning.

The final trainer model successfully simulates real-world electric motorcycle operations, offering students a practical learning experience that bridges the gap between theory and real-world applications. Through structured practical sessions, students can develop their technical competencies in diagnosing electrical circuits, analyzing battery performance, troubleshooting motor controllers, and understanding electronic braking mechanisms. This fully developed electric motorcycle trainer serves as a valuable asset in automotive engineering education, preparing students for future roles in the electric vehicle industry by providing real-time exposure to modern EV technology.

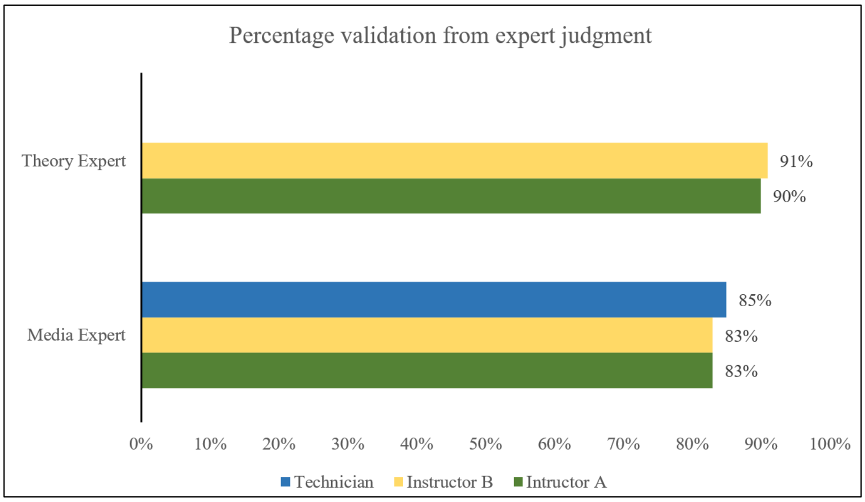

Figure 4. Diagram Percentage Validation from Expert Judgment

Figure 4 presents the percentage validation results from expert judgment, specifically focusing on content and media experts (theory experts). The evaluation process involved three key evaluators: a Technician, Instructor A, and Instructor B, who assessed the suitability of the developed electric motorcycle trainer for practical learning in electric vehicle technology courses at the Automotive Engineering Education Laboratory, UPI. The evaluation process included a thorough review of the trainer's content and media elements, as well as practical demonstrations to assess its suitability for educational purposes.

The content expert validation results yielded an average percentage score of 90.5%, with Instructor B giving the highest rating at 91%, followed by Instructor A with 90%. The trainer was unanimously deemed highly suitable for educational purposes, instilling confidence in its effectiveness. The evaluators did note that the control board markings need improvements, but these are minor and do not detract from the overall suitability of the trainer for educational use. Similarly, the media expert validation obtained an average percentage score of 83.7%, with a Technician rating of 85%, while Instructor A and Instructor B provided 83% ratings. The multimedia experts were particularly impressed with the integration of multimedia elements into the electric vehicle trainer, which they found to be highly effective for learning purposes. They did suggest increasing the variation in cable color markings, but this does not diminish the overall effectiveness of the multimedia elements.

Overall, these validation results confirm that the trainer model is highly feasible for practical training within the automotive engineering program. However, minor labeling and color coding system revisions are recommended. These revisions, if implemented, will optimize the user experience by making the trainer more intuitive and user-friendly, and enhance its instructional effectiveness in real-world educational settings by reducing confusion and improving learning outcomes.

Figure 5 presents the percentage of responses from students, the key stakeholders, regarding the eligibility and effectiveness of the electric motorcycle trainer as a learning medium. Most students responded positively, with 63% strongly agreeing (SA) and 26% agreeing (A) that the trainer is suitable for practical learning. This indicates that nearly 90% of students responded positively to the media, affirming its effectiveness in enhancing their understanding of electric vehicle technology.

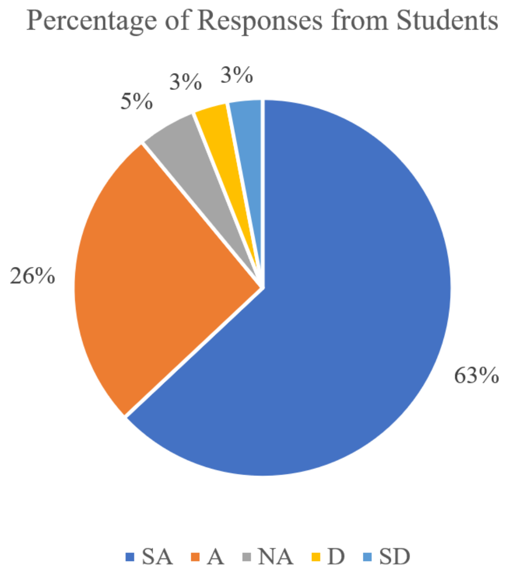

Figure 5. The Percentage of Student Responses Using a Questionnaire

Meanwhile, a smaller percentage of students exhibited neutral or negative responses. 5% of students neither agreed nor disagreed (NA), suggesting that their input is crucial for further improvements. Additionally, 3% disagreed (D), and another 3% strongly disagreed (SD), indicating that some students found the media less effective or challenging. Overall, these results suggest that the electric motorcycle trainer is highly feasible and well-received by students. The overwhelmingly positive responses, with 63% strongly agreeing and 26% agreeing, validate the integration of this trainer in practical courses, reinforcing its importance in vocational education settings.

Discussion

Trainers play a pivotal role as educational aids in electric motorcycles. In the dynamic field of electric motorcycles, where the aim is to grasp the intricate principles of electric vehicle technology, various instructional methods have been employed to ensure comprehensive learning experiences. Among these methods, the utilization of electric motorcycle trainers stands out as a particularly effective approach. These trainers are specifically designed to simulate real-world scenarios and practical applications, providing students with hands-on experience and deepening their understanding of electric vehicle technology.

Furthermore, the instructional framework incorporates supplementary materials such as job sheets and manual books, which are designed to provide comprehensive support for the practical learning facilitated by trainers. Job sheets offer structured guidance for students to engage in practical tasks related to electric motorcycle technology, reassuring them that they can apply theoretical knowledge in a practical setting. Similarly, manual books serve as comprehensive references, providing detailed explanations, diagrams, and troubleshooting guides to further support students' learning journey.

By integrating electric motorcycle trainers, job sheets, and manual books, a multifaceted learning environment is created. This approach is designed to cater to students' diverse needs and learning styles, ensuring that they receive a comprehensive education in electric vehicle technology. The combination of theoretical knowledge with practical application equips students with the necessary skills and expertise to excel in this field and contribute to its ongoing advancements.

Based on research Rindaryati et al. (2022), this research is a PLC trainer product integrated with a pneumatic system. The validation of the research results shows that the trainer has met the validity principle, with an achievement level of 0.95. The principle of practicality has also been fulfilled, with 92.44 teachers and 91.69 students stating that it is practical. Testing the effectiveness of the developed media obtained an average increase in the value score by 20%. The media trainer is practical and effective for use in learning.

Based on the findings of the discussion and research conducted by Firdaus and Zuhrie (2021) on job sheets and trainer learning media, the average validity rating for the job sheets was determined to be 93.36%, indicating that the job sheets are highly valid as a learning medium. Similarly, the trainer's average validity rating was 92.18%, signifying that the robotic arm trainer is also highly valid as a learning medium. The effectiveness of these learning media can be observed through the enhancement of learning outcomes achieved. Furthermore, the practicality of the job sheets and trainer is demonstrated by analyzing student responses. The results from the analysis of student questionnaires revealed an average score of 90.92%, which aligns well with the findings of this study.

In the research Junaidi and Suprianto (2020) on the development of Trainers and Programmable Logic Controller (PLC) Job Sheets in the Electric Motor Installation Subject at Semen Gresik Vocational School, the validation results of the trainer learning media yielded an average score of 86.11%, categorizing it as very eligible. Similarly, the job sheet learning media achieved an average score of 87.35%, which was also categorized as very feasible. Consequently, the overall learning media, utilizing trainers and job sheets in electric motor installation subjects, is deemed highly valid, with a rating of 86.73%. The practicality of interactive learning media was assessed through student response questionnaires. Feedback from a class of 30 students indicated that learning with job sheets was perceived as very practical, with a rating of 89%. Similarly, using PLC and conveyor media trainers was rated very practical, obtaining a rating of 89.25%. Consequently, learning media employing trainer applications and job sheets are highly practical when utilized by students during the learning process.

The electric motorcycle trainer learning media offers several advantages over previous research endeavors. One significant advantage is its proven effectiveness as an innovative learning media product, which has been widely acknowledged by participants. Additionally, the compact design and easy disassembly of this media trainer enhance its practicality and usability. Moreover, the electric motorcycle trainer facilitates lecturers in delivering hands-on learning experiences within electric vehicle technology courses. The inclusion of learning job sheets and a manual book further aids practical learning, allowing users to effectively comprehend each component's functions and specifications.

The effectiveness of electric motorcycle trainers in enhancing practical learning is undeniable; however, several limitations must be addressed. The trainer model utilized in this study is still in its early development stages, requiring further refinement to improve its usability and adaptability. Additionally, limited access to specialized components for electric motorcycle trainers poses a challenge to its widespread implementation across different educational institutions. Variations in students' familiarity with electric vehicle systems also impact the learning curve associated with using the trainers, necessitating additional instructional support. Moreover, this study was conducted within a single institution, limiting the generalizability of the findings. To validate the broader applicability of this approach, further research involving diverse educational environments is necessary.

The findings of this research hold significant implications for technical and vocational education, particularly in preparing students for the evolving automotive industry. Integrating trainers into electric vehicle technology courses fosters hands-on learning, increases student engagement, and enhances practical comprehension, ultimately contributing to workforce readiness in emerging automotive technologies. Furthermore, this study reinforces the importance of structured learning tools, such as job sheets and manuals, in improving student learning outcomes. For educators, these findings highlight the necessity of incorporating practical simulations into vocational curricula to ensure alignment with industry demands and equip students with relevant technical skills.

From a technological perspective, this study contributes to developing modular and scalable trainers, enabling continuous innovation in electric vehicle education. The trainer's compact and easily disassembled design enhances portability and accessibility, making it a viable solution for institutions with limited laboratory space or financial constraints. This adaptability ensures that more students can access hands-on training, regardless of institutional resources.

Future research should explore several critical areas to build upon the current findings. A comparative study between electric motorcycle trainers and alternative learning media, such as virtual reality simulations or augmented reality models, could provide valuable insights into the most effective teaching methodologies. Additionally, long-term studies should assess the impact of trainer-based learning on student competencies and industry preparedness. Expanding research through collaborations with multiple institutions and industry partners would further validate the effectiveness of trainers in real-world automotive training programs. Lastly, future studies should investigate cost-effective strategies for scaling the production and distribution of trainers, ensuring their broader adoption in vocational education settings.

CONCLUSION

The findings of this study confirm that the electric motorcycle trainer is a highly functional and effective learning tool, as validated through multiple expert and student assessments. The evaluation conducted by content experts resulted in an impressive average score of 90.5%, categorizing the trainer as "Very Eligible" for use in practical learning. Similarly, media experts provided positive feedback, averaging 83.7%, indicating its strong suitability as an instructional aid. Furthermore, the substantial agreement among student respondents, consisting of 47 participants, on the trainer's effectiveness, with 89% agreeing or strongly agreeing with its usability and educational value, should reassure you of its efficacy.

Beyond its effectiveness, the study also highlights key areas for improvement to enhance the trainer's safety and functionality. It is recommended that conductivity materials be incorporated into the [specific components] to reduce the risk of short circuits. Additionally, stricter adherence to safety protocols is necessary, particularly concerning the high-voltage battery system, to ensure a secure and risk-free learning environment. These findings affirm the trainer's viability as an effective educational medium in electric vehicle technology courses. However, ongoing refinement and optimization hold the promise of further enhancing its safety, usability, and educational impact. This ongoing process ensures that it remains an effective tool for vocational training in emerging automotive technologies, instilling a sense of optimism about its future potential.

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