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Development Of An Electric Motorcycle Trainer Kit As A Learning Medium For Electrical Engineering And Automotive Engineering Majors In Vocational High Schools

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Abstract
The increasing demand for electric vehicles (EVs) due to global warming and environmental issues necessitates specialized knowledge in this field. This research develops an electric motorcycle trainer kit designed to enhance learning in vocational high schools, specifically in the Electrical Engineering and Automotive departments. The research aimed to design and validate a trainer kit that accurately represents an electric motorcycle's electrical system, facilitating hands-on learning for students. The methodology involved data collection, product design, and implementation with validation by field experts. Results showed that the trainer kit significantly improved students' understanding and practical skills related to electric vehicle systems. In conclusion, the electric motorcycle trainer kit proved to be an effective educational tool, supporting the development of competencies required for the growing electric vehicle industry. Further improvements in the aesthetic and technical aspects of the kit could enhance its future applications.

Keywords: *Electric Vehicles, Learning Tool, Trainer Kit, Vocational Education*

INTRODUCTION

Worsening global climate change has become one of the biggest challenges facing humanity today. Greenhouse gas emissions, mostly from the transportation sector, are the main cause of global warming (Feulner, 2017). Along with global efforts to reduce such emissions, electric vehicles (EVs) are emerging as one of the promising solutions. In Indonesia, the adoption of electric vehicles is increasing, with data from the Ministry of Energy and Mineral Resources (MEMR) showing that in 2021 there were approximately 2.73 million units of two- or three-wheeled electric vehicles, and is expected to increase to 4.71 million units by 2024 (Lopez-Arboleda et al., 2021). This trend reflects the importance of education and training to prepare a competent workforce to design, develop and maintain electric vehicles (Tasrif, 2021).

A review of previous literature shows that various studies on electric vehicles have been conducted, including the conversion of fueled motorcycles to electric and the development of environmentally friendly and economical electric motors (Kristyadi et al., 2021; Jondra & Sugiarta, 2021). However, most of these studies focus more on the vehicle technology itself rather than the development of learning media that can be used to train a skilled workforce in this field. Research relevant to the development of learning media based on electric vehicle technology is still very limited (Suryanto & Prasetya, 2021). Therefore, a more in-depth study of learning media that can facilitate students in understanding electric vehicle systems better is needed.

This article offers scientific novelty in the form of developing an Electric Motorcycle Trainer Kit as a learning medium at Vocational High Schools (SMK). The Trainer Kit is designed to provide a hands-on learning experience that approaches the reality of the electric vehicle industry, with a modular approach that allows students to study each component of an electric vehicle separately. The existence of this Trainer Kit not only helps students understand the electrical system of electric motors, but also allows them to engage in maintenance and repair simulations (Zainol et al., 2019). Thus, this learning media is expected to be an effective solution to overcome the lack of competent workforce in the field of electric vehicles in Indonesia.

The development of learning media, such as the Trainer Kit, is crucial in vocational education, as it bridges the gap between theoretical knowledge and practical skills (Prasetyo et al., 2024). Furthermore, the integration of such tools in the curriculum has been shown to enhance students's engagement and motivation, particularly in technical fields (Setyanto et al., 2023). Studies have also highlighted the importance of modular and interactive learning tools in improving students's problem-solving abilities and technical competencies (Zulfian & Wrahatnolo, 2020). Additionally, the use of Trainer Kits in vocational education has been proven to align with industry needs, preparing students for real-world challenges in the electric vehicle sector (Ahmad & Wrahatnolo, 2024).

Moreover, the adoption of electric vehicles is not only a technological shift but also a cultural and economic transformation that requires comprehensive educational strategies (Sidabutar, 2020). The development of learning media that incorporates the latest technological advancements is essential to ensure that students are well-prepared for the evolving demands of the industry. This is particularly important in Indonesia, where the government is actively promoting the use of electric vehicles as part of its sustainable development goals (Wahono & Sukir, 2020).

Based on this background, this study aims to: (1) develop and validate the Electric Motorcycle Trainer Kit as a learning media in Vocational High Schools, (2) measure the effectiveness of using the Trainer Kit in improving student competence related to the electrical system of electric vehicles, and (3) investigate the potential use of the Trainer Kit in increasing student motivation to learn environmentally friendly technology.

METHOD

This research uses the Research and Development (R&D) research method using a modified development procedure (Siregar, 2023). The electric motorcycle Trainer Kit development procedure can be seen in Figure 3.

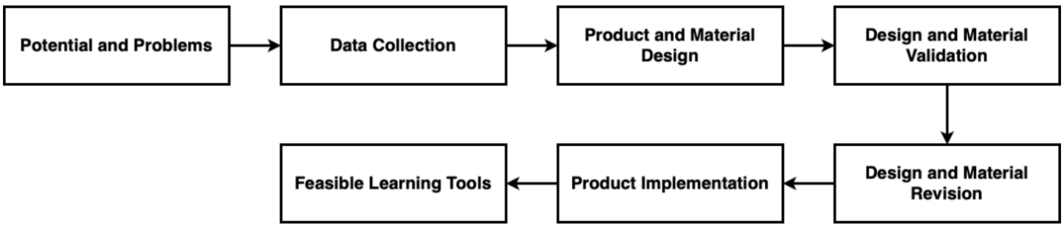

Figure 1. Electric Motorcycle Trainer Kit Development Procedure

A. Identification of Potential and Problems

The initial step in the development procedure is to analyze potential and problems (Kurniawan & Hidayat, 2021). Researchers collaborate with IGVIM partners in Electrical Engineering Vocational High Schools to recognize the potential and problems of learning media innovation needs for electric motorcycle Trainer Kit. Analysis of potential and problems based on the observation process at Electrical Engineering expertise program. The observation results show that the trainers used to fulfill the learning of electric motorcycle technology still use finished products. So, that in this study an electric motorcycle Trainer Kit will be made.

B. Data Collection

The next step after obtaining potential and problems is data collection. Data collection is intended to support potential and problems. Data collection is carried out by (1) analyzing learning media needs; (2) identifying data on the need for tools and materials for the development of Trainer Kit and electric motorcycle jobsheets; (3) analyzing the specifications of Trainer Kit tools and materials and jobsheets; (4) analyzing the components of the electric motorcycle Trainer Kit; (5) analyzing hardware and software requirements; and (6) analyzing learning objectives (TP), flow of learning objectives (ATP), and jobsheets in the Independent Curriculum Teaching Module according to the CP of electric motorcycles.

C. Product and Material Design

Design is a planning process from imagining, analyzing, and creating so that an acceptable product is produced (Sreenivasan & Suresh, 2024). Product design is intended as a design related to the details of the product to be made. Product details designed include specifications, components, benefits and visual product design (Lopez-Arboleda et. al, 2021). In this study, a product design was made with a framework as shown in Figure 2.

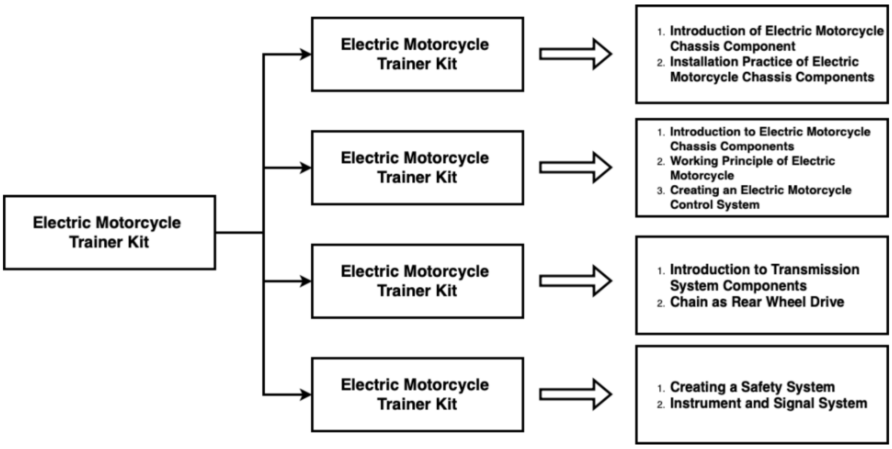

Figure 1. Product Design

D. Design and Material Validation

The product design that has been designed is then carried out design validation to test the validity and feasibility of the product developed (Mustafa & Angga, 2022). Validation is carried out by several related experts. In this study, design validation was carried out by material experts and media experts. Material experts are carried out by lecturers and partners. In design and material validation, there are various aspects that will be assessed by the media validation party and the material validation party, each of which consists of the following.

Table 1. Media Expert Validation Instrument

No.	Assessment Aspect	Description	Value			
			1	2	3	4
1.	Design Appropriateness	Is the Trainer Kit design in accordance with applicable learning media standards?				
2.	Clarity of Visual Display	To what extent is the visualization of components on the Trainer Kit easy to understand by users (students)?				
3.	Media Interactivity	Does it allow for sufficient student interaction in the learning process?				
4.	Ease of Use	Is the Trainer Kit easy to use by students, especially in terms of operation and maintenance?				
5.	Material Quality	Are the materials used in the Trainer Kit durable and safe to use in practice?				
6.	Conformance to Needs	Does the media design fulfill the learning needs in SMK related to electric vehicle technology?				
7.	Aesthetics	Does the Trainer Kit have good visual appeal to students?				
8.	Media Efficiency	Does this media help students learn in a more efficient way?				

Table 2. Material Expert Validation Instrument

No.	Assessment Aspect	Description	Value			
			1	2	3	4
1.	Material Suitability	Is the material delivered through the Trainer Kit in accordance with the basic competencies needed by students?				
2.	Accuracy of	To what extent is the material				

	Material	presented in line with the latest developments in electric vehicle technology?	
3.	Clarity of Material Delivery	Is the material presented clearly and easily understood by students?	
4.	Conformance to Curriculum	Is the material in the Trainer Kit in accordance with the applicable curriculum in SMK?	
5.	Depth of Material	Is the material presented in sufficient depth to support student competency in this area?	
6.	Relevance to Skills	Are the learning materials relevant to the skills required in the electric vehicle industry?	
7.	Material Integrity	Is the material in the Trainer Kit well integrated between modules or learning topics?	
8.	Usability	Is this material suitable for use as a learning tool in vocational schools?	

Table 3. Assessment Categories

Value Range (%)	Category
60 – 69	Not Feasible
70 – 79	Decent Enough
80 -89	Worth
90 - 100	Very Feasible

E. Product Revision

The product design has been corrected based on input from media experts and material experts. Media experts and material experts provide correction notes that have been considered and followed up by researchers. The process of revising and improving the design has been completed, so that the resulting product is declared valid and ready for testing (Wahono & Sukir, 2020; Zulfian & Wrahatnolo, 2020).

F. Product Implementation with Students

Product trials are conducted on a wider scale, by conducting direct evaluations in classrooms or laboratories [10]. The aim is to collect learners' responses to the electric motorcycle Trainer Kit that has been made. This process provides an overview of the real conditions of product performance and allows identification of advantages and potential improvements. The results of this trial form the basis for improving the design and quality of the product, before it is introduced more widely in the market. In the final stage to measure students' ability to understand electric motors after applying the Electric Motorcycle Trainer Kit in the learning process, a written test is used as an indicator of student understanding which is arranged in the following form:

Table 4. Student Test Validation Instrument

Material	Question Item	Cognitive Level	Question No.
Electric Motorcycle Introduction and Operation	Name the main components found in an electric motorcycle!	C1 (Understanding)	1,2
	How does an electric motor convert electrical energy into mechanical energy?	C2 (Understanding)	3,4
	List the steps of operating an electric motorcycle from the beginning until the motorcycle can run!	C3 (Applying)	5,6
	Describe the routine maintenance procedures required to maintain the performance of an electric	C2 (Understanding)	7,8

	motorcycle!		
	If an electric motorcycle won't start even though the battery is fully charged, what are the first steps to diagnose the problem?	C4 (Analyzing)	9.10
Electric Motorcycle Control and Charging	Why is a controller important in an electric motorcycle, and how does it manage the flow of electricity to the motor?	C2 (Understanding)	11,12
	What is the safe procedure for charging the battery on an electric motorcycle to avoid the risk of damage or danger?	C3 (Applying)	13,14
	What should be done to measure the performance of an electric motorcycle battery, and how to read the correct measurement results?	C4 (Analyzing)	15,16
	What steps need to be taken regularly to maintain and extend the life of the battery on an electric motorcycle?	C2 (Understanding)	17,18
	When the battery of an electric motorcycle is not charging well, what analysis can be done and how to determine the right solution?	C4 (Analyzing)	19,20
Safety and Handling of Electric Motorcycles	What are the safety measures to observe when operating an electric motorcycle to avoid accidents?	C1 (Understanding)	21,22
	Why is personal protective equipment (PPE) so important when working with electric motorcycles, and what PPE is required?	C2 (Understanding)	23,24
	What are the emergency procedures to take in the event of a breakdown or accident while using an electric motorcycle?	C3 (Applying)	25,26
	How to safely store and handle electric motorcycle batteries to avoid the risk of fire or explosion?	C2 (Understanding)	27,28
	What are the possible risks of operating an electric motorcycle, and how can you prevent them to stay safe?	C4 (Analyzing)	29,30

RESULTS AND DISCUSSION

1. Research Results

1.1 Trainer Topology Design

The results of this study resulted in the design of an electric motorcycle Trainer Kit product specifically designed to be used as a learning aid in Vocational High Schools (SMK). This product design emphasizes similarity to the original components of an electric motorcycle, but with modifications that allow for easier use and understanding for students. The Trainer Kit consists of several main parts, including an electric motor, battery, controller, charging system, as well as a modularly designed control panel. Each component is designed to be detachable, allowing students to thoroughly understand the workings and interactions between components in an electric motorcycle system. This modular design also makes it easy to replace components to simulate various breakdown and repair scenarios, thus improving students' troubleshooting skills.

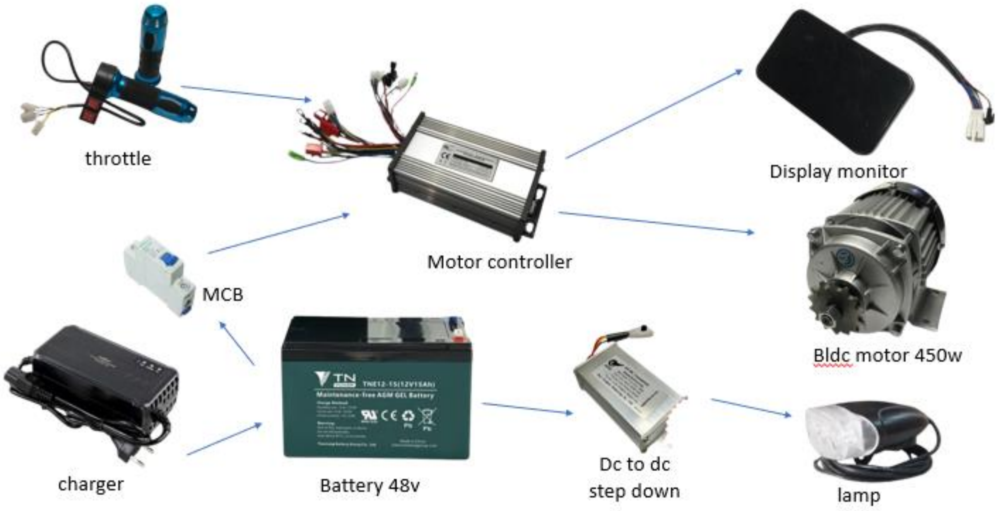

Figure 2. Topology Design

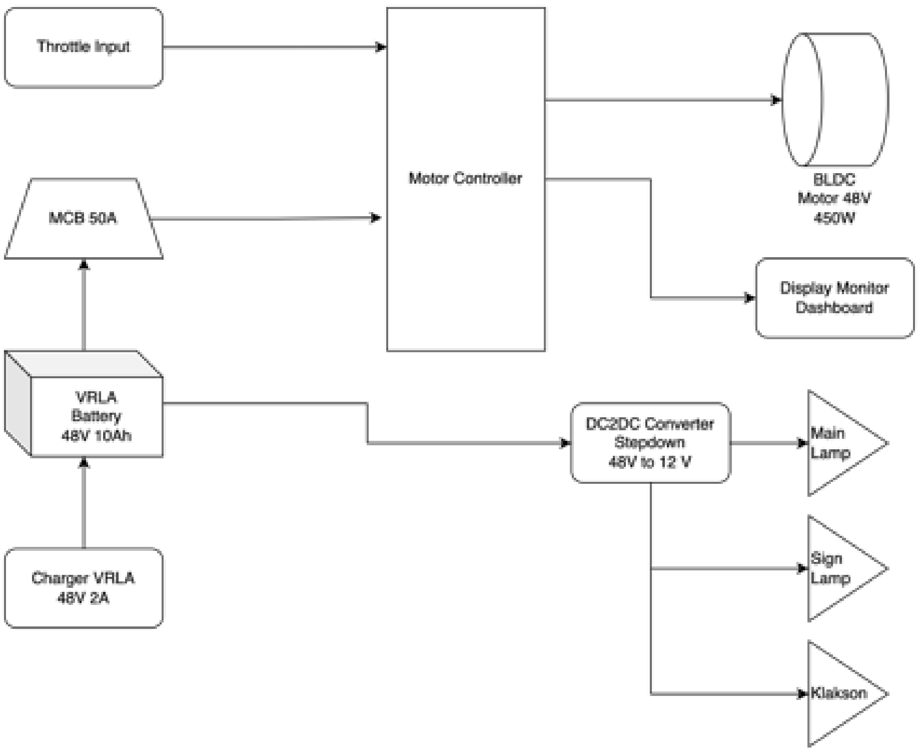

Figure 3. Abstract Design

Figure 4. Framework Design

The learning materials in this Trainer Kit design cover both theoretical and practical aspects, focusing on the operation, maintenance, and repair of electric motorcycles. The material is organized in stages, starting from an introduction to the basics of electric vehicle systems to advanced techniques in diagnosis and repair. Each learning session is designed to give students hands-on experience in operating the Trainer Kit, which includes simulating real problems and applying solutions independently. With comprehensive materials and in accordance with the latest technological developments, students are expected to be able to master the competencies needed to work in the electric vehicle industry and be ready to face future challenges. The material outcomes developed are adjusted to the learning outcomes and learning objectives in the electric power installation engineering department, namely:

Table 5. Common Outcomes and Learning Elements

General Achievements	Achievement of Electric Motor Installation Elements
At the end of phase F, learners are able to apply standards and regulations in electrical power installation work and understand control systems. Learners are also able to carry out electrical lighting installation work, electrical power installation, electrical motor installation, electrical equipment repair, and maintenance and repair of power lighting and electrical motor installations	At the end of phase F, learners are able to carry out the installation of electric motor installations from planning, installation, testing and reporting. Learners can carry out planning which includes working drawings, equipment and material requirements, and costs. Learners can carry out installation and testing of 1 phase and 3 phase electric motor installations with various devices, instrumentation and control, and protection according to technical standards. Learners are also able to make reports.

1.2 Design and Material Validation

In this study, validation was carried out to ensure that the designed electric motorcycle Trainer Kit met quality standards in terms of media and learning materials. This validation is carried out by media experts and material experts who provide an assessment of several important aspects related to the effectiveness and efficiency of the Trainer Kit design and the suitability of learning materials. The validation process involves evaluating the design components, the suitability of the material content with learning objectives, ease of use, and the potential for increasing student competence. The following is a validation instrument that has been tested to media and material experts.

Table 6. Media Expert Instrument Validation

No.	Assassment Aspect	Value
1.	Design Appropriateness	4
2.	Clarity of Visual Display	4
3.	Media Interactivity	4

4.	Ease of Use	4
5.	Material Quality	4
6.	Conformance to Needs	4
7.	Aesthetics	3
8.	Media Efficiency	4
Total		31

Based on data from Table 3: Assessment Categories, the total value obtained from the Media Expert Instrument Validation is 31. If the total maximum value for the eight aspects of the assessment is 32 (8 x 4), then the percentage of the value obtained is:

Percentage of Scores = $\frac{31}{32} \times 100\% = 96.875\%$

According to the range of values in Table 3, with a percentage of 96.875%, the assessment category is included in the Very Feasible category (90 - 100%). This shows that the evaluated media is considered very feasible by media experts in terms of design suitability, visual appearance, interactivity, ease of use, quality of materials, suitability to needs, aesthetics, and efficiency.

Table 7. Material Expert Instrument Validatioon

No.	Assassment Aspect	Value
1.	Material Suitability	4
2.	Material accuracy	4
3.	Clarity of Material Delivery	4
4.	Conformance to Curriculum	4
5.	Depth of Material	4
6.	Relevance to Skills	4
7.	Material Integrity	4
8.	Usability	3
Total		31

Based on data from Table 3: Assessment Categories, the total value obtained from the Media Expert Instrument Validation is 31. If the total maximum value for the eight aspects of the assessment is 32 (8 x 4), then the percentage of the value obtained is:

Value Percentage = $1\frac{31}{32} \times 100\% = 96.875\%$

According to the range of values in Table 3, the percentage of 96.875% falls into the Very Feasible category (90 - 100%). This indicates that from the perspective of the material expert, the learning media evaluated is very feasible to use. The aspects assessed include suitability, accuracy, depth of material, alignment with the curriculum, and relevance to the skills to be achieved, all of which support the feasibility of using this media.

The results of the validation of the instrument design that has been made both from the assessment of media aspects and material aspects each have a value close to perfect, which means that the design of the electric motorcycle Trainer Kit is ready to be used as a student learning media. Although it is ready to be used as a learning medium, in the design of this electric motorcycle Trainer Kit there are several things that can still be developed starting from the aesthetic design of the model that can be made more attractive and the use of newer components and technology so that students can always keep up with the development of existing electric motorcycle technology.

1.3 Student Competency Outcomes

Implementation of the electric motorcycle Trainer Kit design to students in Vocational High Schools in terms of their understanding and practical skills related to electric vehicle technology. Testing is carried out during the learning process, students are actively involved in implementing the Trainer Kit. The use of the Trainer Kit also encourages increased student learning motivation. Students are expected to feel more confident in trying and experimenting with various practical scenarios. The following table shows the results of student implementation achievements:

Table 8. Student Implementation Outcome Table

Score	Category	Number of Students	Students (%)
50-60	Very Low	2	5
61-70	Low	3	7
71-80	Simply	1	3
81-90	High	5	12
91-100	Very High	29	73

Total	40	100%

The implementation results showed that the majority of students (73%) were in the "Very High" category with scores between 91-100. This indicates that most students were able to very well understand and apply the practical skills needed in using the electric motorcycle Trainer Kit. Meanwhile, 12% of students were in the "High" category with a score of 81-90, and a small proportion of students (3%) obtained the "Fair" category with a score of 71-80. A total of 5% of students are in the "Very Low" category with a score of 50-60, and another 7% of students are in the "Low" category with a score of 61-70, indicating that some students need further guidance in understanding the material.

Overall, the use of the Trainer Kit not only improved students' technical understanding, but also fostered their confidence in attempting various practical scenarios. These results reflect the effectiveness of the Trainer Kit in improving students' practical skills and understanding of electric vehicle technology.

2. Discussion

Along with the rapid development of electric vehicle technology, the application of electric motorcycles as learning media in Vocational High Schools (SMK) is very relevant. By integrating this technology in the curriculum, students can acquire skills that match the needs of the modern automotive industry. The design of an electric motorcycle designed for educational purposes not only facilitates technical understanding, but also prepares students for future challenges (Wiguna et al., 2020).

2.1 Electric Motorcycle Design for Learning

The design of the electric motorcycle adopted for learning purposes in Vocational High Schools has distinctive characteristics that differentiate it from conventional motorized vehicles. One key aspect is the modularity of the design, which allows students to learn each component separately before understanding the system as a whole. This modularity not only facilitates teaching but also provides flexibility in the curriculum, which is very important in vocational education (Widodo & Santoso, 2020 ; Kurniawan & Hidayat, 2021).

Electric motorcycles for learning generally include key components such as the drive motor, battery, and electronic control system separated into separate modules. This approach allows students to learn gradually, starting from the basic components to the integration of the system as a whole (Andriyani & Nugroho, 2019). This modularity also makes it easier for students to understand basic principles such as electrical systems and battery management that are important in electric vehicles. Another advantage of this design is ease of maintenance and repair. Electric motorcycles have fewer moving parts than conventional motorcycles, which makes the process of maintenance and fault diagnosis simpler. This is particularly beneficial in an educational context, where students can more easily understand and practice repair techniques (Suryanto & Prasetya, 2021).

In addition, electric motorcycle designs often include environmentally friendly features, such as the use of rechargeable batteries and efficient charging systems. These features not only support educational goals related to green technology but also provide students with insights into sustainability in the automotive industry (Hakim & Sudrajat, 2022).

2.2 Skills Development of Vocational Students through Electric Motorcycle Learning

The use of electric motorcycles as learning media has a significant impact on the development of technical skills of vocational students. In this context, students acquire practical skills in the assembly, maintenance, and diagnosis of electric vehicles. These skills are very relevant to the needs of the growing automotive industry, especially in the context of electric vehicles (Prasetyo & Siregar, 2020).

Through electric motorcycle-based learning, students can practice their technical skills in component assembly, control system programming, and battery system management. This gives them a deeper understanding of how the electrical and control systems used in electric vehicles work (Kurniawan & Hidayat, 2021). In addition, students learn to use sophisticated diagnostic tools to analyze and resolve technical issues that may arise during the use of an electric motorcycle.

Electric motorcycle-based learning also teaches students about safety in handling high-voltage electrical systems. This knowledge is important to ensure that students not only understand how the system works, but also how to handle the equipment safely (Andriyani & Nugroho, 2019). In addition to technical skills, students are also taught about safety procedures that involve the use of personal protective equipment and safety techniques when working with batteries and electrical systems.

2.3 Relevance to Industry and Future Challenges

The application of electric motorcycles in the Vocational High Schools`s curriculum is very relevant to the automotive industry trend that is currently shifting to electric vehicle technology. Many countries, including Indonesia, are developing policies to promote the use of electric vehicles as a more environmentally friendly alternative (Hakim & Sudrajat, 2022). Thus, students who gain learning in electric vehicle technology will have a competitive advantage in a labor market that is increasingly focused on green technology and sustainability.

Research also shows that the integration of electric motorcycles in the Vocational High Schools`s curriculum helps synchronize students' skills with industry needs. Students who are equipped with knowledge and skills related to electric vehicles will be better prepared for the evolving demands of the industry, such as battery system management, charging technology, and control system programming (Suryanto & Prasetya, 2021). This knowledge not only enhances students' technical skills but also prepares them for more innovative roles in the future.

2.4 Students' Motivation and Interest in Learning Electrical Technology

The use of electric motorcycles in learning also contributes to increased student motivation and interest. New technologies that are considered innovative and relevant to current needs tend to be more attractive to students. Research shows that students who engage in project-based learning with electric motorcycles show higher levels of engagement compared to traditional learning methods (Prasetyo et al., 2020). This method also provides a more practical and enjoyable learning experience, which improves understanding and retention of information.

Electric motorcycle-based learning allows students to be directly involved in design experiments and modifications, which encourages them to think creatively and innovatively. The ability to conduct experiments and see the tangible results of the modifications made provides additional impetus for students to continue learning and exploring new technologies (Kurniawan & Hidayat, 2021). It also contributes to the development of problem-solving skills that are crucial in the automotive industry.

CONCLUSION

This research on the Development of an Electric Motorcycle Trainer Kit as a Learning Media concluded that the modular and efficient design of the Trainer Kit has successfully facilitated the learning process of students at Vocational High Schools. This modular design allows students to study each component of an electric motorcycle separately, such as the electric motor, battery, controller system, and charging. With detachable modules, students can more easily understand how each component works, as well as hone their troubleshooting skills. This design also provides flexibility in learning, as each component can be simulated for various repair scenarios, which greatly supports practical learning.

In addition, the use of this Trainer Kit significantly improved students' technical competence. Evaluation of students' skills showed that the majority of students achieved a very high level of understanding. They are not only able to understand how electric vehicle components work, but can also plan, install, and test the installation of electric motor electrical systems. These results show that the Trainer Kit is effective in preparing students for the growing demands of the electric vehicle industry, as well as supporting the achievement of student competencies in accordance with industry standards.

This research also emphasizes the importance of compatibility between learning materials and the needs of the automotive industry. The curriculum developed based on the use of this Trainer Kit has been adapted to the development of electric vehicle technology, so that students trained with this media are better prepared to enter the world of work. This is very relevant to the increasing trend of electric vehicle adoption globally and in Indonesia, where the ability to maintain, repair, and develop electric vehicle technology is very much needed. The use of this Trainer Kit not only has an impact on improving technical skills, but also increases students' motivation and interest in learning electrical technology. With a more interactive project-based learning approach, students are more motivated to be actively involved in the learning process. They can experiment directly with new technologies, which makes learning more interesting and relevant to today's industrial needs.

This research is also relevant to environmental issues and future technologies. Electric motorcycles, which are environmentally friendly and contribute to the reduction of greenhouse gas emissions, make ideal learning tools to prepare students for the demands of an industry that is shifting to green technology. With an awareness of sustainability and climate change, students not only master technical skills, but also gain insight into the importance of green technology.

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