


## Implementation of Electric Vehicle Kit (EV-KIT) to Improve the Competence of Automotive Technology Vocational Education Students at Ahmad Dahlan University in Electric Vehicle Knowledge

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### Abstract

The rapid development of electric vehicle (EV) technology has created an urgent need for vocational students to master the concepts and practical knowledge of electric power systems in automotive applications. However, the lack of appropriate learning media and limited access to real EV components have made it difficult for students to understand the relationship between theoretical knowledge and its practical application. This study aims to implement an *Electric Vehicle Kit (EV-KIT)* as an innovative learning medium to improve students' understanding of electric vehicle components and working systems in the *Pendidikan Vokasional Teknologi Otomotif (PVTO)* Program at Universitas Ahmad Dahlan. The research used a Research and Development (R&D) approach with the ADDIE model, consisting of five stages: analysis, design, development, implementation, and evaluation. The product was validated by three experts and tested through two trials involving 6 students in a limited trial and 19 students in an expanded implementation. Data were collected using observation sheets, questionnaires, and pre-test and post-test instruments, then analyzed using descriptive statistics and a *paired sample t-test*. The validation results showed that the EV-KIT achieved a feasibility level of 88.4%, categorized as "very feasible." The average *N-Gain* score of 0.65 indicated a moderate to high improvement in students' knowledge of EV components and their functions. Furthermore, students' responses reached 86.7%, categorized as "very good," showing that the EV-KIT is practical, safe, and effective in supporting active and project-based learning. The implementation of EV-KIT not only improved students' conceptual understanding but also enhanced their motivation and readiness to face the transition toward electric vehicle technology in the automotive industry. Therefore, the EV-KIT is recommended as an alternative instructional media for vocational and higher education to strengthen competence in electric vehicle systems.

**Keywords:** Electric Vehicle Kit, Vocational Education, Automotive Learning, Electric Vehicle Components, Project-Based Learning

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## INTRODUCTION

The development of electric vehicle technology has become a major focus in the transformation of the global automotive industry (Burhan & Arifin, 2020; Yanto et al., 2023). The shift from fossil-fueled vehicles to electric vehicles represents a concrete effort to reduce carbon emissions and support energy sustainability. This has a direct impact on the need for human resources competent in the fields of electric power systems and vehicle automation. Vocational higher education institutions, including the Automotive

Technology Vocational Education Study Program (PVTO) at Ahmad Dahlan University, have a responsibility to prepare graduates who are adaptive to these technological changes. Therefore, a learning strategy that integrates theory with practice in the context of electric vehicles is needed (Anthony et al., 2022; Liu et al., 2020).

Electric vehicles have different technical characteristics than conventional vehicles, particularly in their propulsion systems, energy storage, and electronic controls. Students need to understand the basic concepts of batteries, electric motors, controllers, and charging systems. However, observations and interviews with PVTO lecturers and students indicate that understanding of electric vehicle systems is still limited, particularly in practical aspects. Limited practical facilities result in a more theoretical learning process, resulting in limited hands-on experience for students with electric vehicle systems. This situation underscores the need for innovative, applicable learning media (Kanife et al., 2022; Suyitno et al., 2022).

One solution that can be developed is the use of an Electric Vehicle Kit (EV-KIT) as an interactive learning medium. An EV-KIT is an educational tool designed to simulate electric vehicle systems in a simple yet comprehensive way (Chernikova et al., 2020; Curiel-Ramirez et al., 2022). This kit allows students to directly assemble, operate, and analyze the main components of an electric vehicle. By using an EV-KIT, students can understand the relationship between automotive electrical theory and its practical application. This medium also serves as a means to foster critical thinking and technical problem-solving skills (Feijoo-Garcia et al., 2024; Kesler et al., 2022).

The EV-KIT-based learning innovation aligns with the Project-Based Learning (PjBL) concept, which emphasizes active student involvement in the learning process. Through a project-based approach, students can identify technical problems, design solutions, and implement miniature electric vehicle systems. This activity fosters a collaborative, creative, and responsible attitude towards teamwork. Furthermore, project-based learning enhances students' conceptual understanding through hands-on experience. Thus, the EV-KIT serves not only as a learning tool but also as a vehicle for developing professional competencies (Åkerblom et al., 2023; Ariza & Olatunde-Aiyedun, 2023; Liao et al., 2023).

The implementation of the EV-KIT also supports the 21st-century learning paradigm, which demands the integration of Science, Technology, Engineering, and Mathematics (STEM). Students are required to be able to connect scientific theory with its application in modern automotive technology (Ariza & Olatunde-Aiyedun, 2023). Through the EV-KIT, they can learn the physical principles of force and energy, understand the mechanisms of converting electricity into motion, and apply the principles of electrical systems engineering. This cross-disciplinary integration is expected to improve technological literacy and prepare students to face the challenges of the future electric vehicle industry (El Hadraoui et al., 2022; Qiu et al., 2023).

The readiness of higher education institutions to develop technology-based learning is key to the successful transformation of vocational education. In the context of Ahmad Dahlan University's PVTO, the development of media such as the EV-KIT can be a strategic step to improve the quality of modern automotive education (Antunes et al., 2023; Chudzikiewicz et al., 2024). The use of the EV-KIT not only supports the achievement of graduate learning outcomes but also strengthens the relationship between academia and the automotive industry. Thus, students not only understand the theory of electric vehicle systems but also gain practical experience relevant to the needs of the workplace.

Several previous studies have shown that the use of practice-based learning media can improve learning outcomes and student motivation. For example, research by Wegig Pratama & Bambang Sudarsono (2024) demonstrated that technology-based learning media effectively improved students' understanding of complex and high-risk concepts, such as occupational safety. A similar approach can be applied to electric vehicle learning,

where the use of interactive media such as the EV-KIT can enhance the learning experience and accelerate student understanding. Therefore, this study adapts a technology-based media development approach to the context of electric automotive learning (Wangsupphaphol et al., 2023).

The use of the EV-KIT is expected to address the gap between theory and practice that has existed in electric vehicle education. Through this tool, students can directly learn about electric vehicle drivetrain systems without the need for expensive and difficult-to-access real vehicles. Through hands-on experimentation, students can understand how power systems work, regulate electric current, and the energy efficiency of electric vehicles. This hands-on learning is expected to significantly improve students' technical skills (Liao et al., 2023).

In addition to strengthening knowledge and skills, the use of the EV-KIT also has the potential to increase students' learning motivation. The experience of assembling and operating a simple electric vehicle system can foster curiosity, creativity, and a spirit of exploration of new technologies (Hsiao et al., 2022). Contextual and interactive learning activities also encourage students to be more active and enthusiastic in understanding the concept of vehicle electrification. Thus, the EV-KIT serves not only as a learning tool but also as a motivational medium that strengthens students' scientific attitudes (Selcuk et al., 2024; Soomro et al., 2023).

In the long term, the development and implementation of the EV-KIT within the UAD PVTO environment is expected to become an innovative learning model in the field of automotive vocational education (Tiryaki & Adigüzel, 2021; Wahono et al., 2020). This product can be replicated and further developed by other educational institutions to support electric vehicle-based automotive curricula. Furthermore, the EV-KIT also opens up opportunities for collaboration between universities, vocational schools, and the automotive industry in developing research-based applied learning. With this synergy, the transformation of vocational education towards the era of vehicle electrification can be realized sustainably (Khalil et al., 2023; Wright & Li, 2016).

Based on the description above, this study aims to implement the Electric Vehicle Kit (EV-KIT) as a learning medium for students of Automotive Technology Vocational Education at Ahmad Dahlan University. The research focuses on the development, implementation, and evaluation of the effectiveness of the EV-KIT in improving students' knowledge competency about electric vehicle systems. The results of this study are expected to be a reference in the development of innovative learning media that are relevant to the needs of the modern automotive industry and support the vision of PVTO UAD as a superior study program in the field of vocational education and automotive technology with an entrepreneurial spirit (El Hadraoui et al., 2022; Qiu et al., 2023).

## **METHOD**

This study uses a Research and Development (R&D) approach with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model to produce and test Electric Vehicle Kit (EV KIT) learning media. The study was conducted at the Automotive Laboratory of the Automotive Technology Vocational Education Study Program (PVTO) at Ahmad Dahlan University in the even semester of the 2025 academic year. The purpose of this study is to implement EV KIT to improve students' knowledge competency about electric vehicle systems.

The analysis phase was conducted by identifying learning needs through observation, interviews with lecturers, and distributing questionnaires to students. The analysis revealed that students' understanding of electric vehicle systems remained low due to limited practical tools. Based on these findings, the EV KIT was developed as a practical learning tool capable of simulating electric vehicle operation simply and safely.

The design phase includes the design of an EV KIT system consisting of a battery, electric motor, controller, indicator system, and miniature vehicle frame. Safety, ease of use, and compliance with the PVTO curriculum were key considerations. Project-based learning modules and user manuals were also developed to enable students to learn independently. The design was then validated by media and subject matter experts to ensure the device's functionality and suitability.

The development phase involved creating an EV KIT prototype and validation by three validators (automotive experts, media experts, and industry practitioners). Assessment was conducted using a Likert scale of 1–5, with the following formula:

$$P = \frac{\text{Obtained Score}}{\text{Maximum Score}} \times 100\%$$

Validation results are categorized as follows: 0–20% (Very Unfeasible), 21–40% (Unfeasible), 41–60% (Quite Feasible), 61–80% (Feasible), and 81–100% (Very Feasible). Products that obtain a score of  $\geq 61\%$  are declared feasible for implementation (Suyitno et al., 2022).

The implementation phase was conducted through two trials: a limited trial with six students and an expanded trial with 19 students in the Electric Vehicle Technology course. Data was obtained through pre- and post-tests to assess learning outcomes, as well as a questionnaire to assess user responses. Learning outcomes were calculated using the N-Gain formula:

$$N\text{-Gain} = \frac{S_{\text{post}} - S_{\text{pre}}}{S_{\text{maks}} - S_{\text{pre}}}$$

Improvement categories:  $g \geq 0.70$  (High),  $0.30 \leq g < 0.70$  (Medium), and  $g < 0.30$  (Low).

Student responses to the EV KIT were measured using a questionnaire with a scale of 1–5 and converted to percentages. The categories include: 0–20% (Very Poor), 21–40% (Poor), 41–60% (Fair), 61–80% (Good), and 81–100% (Very Good). The EV KIT is declared effective if the N-Gain is at least in the moderate category ( $\geq 0.30$ ) and the user response is at least good ( $\geq 61\%$ ) (Sudarsono et al., 2024).

The evaluation stage was conducted to assess the overall feasibility and effectiveness of the product through formative and summative evaluations. Data analysis was conducted qualitatively to describe student responses and experiences, and quantitatively using a paired sample t-test to determine significant improvements in learning outcomes. Success criteria were determined based on three aspects: (1) minimum validation results of "Feasible" ( $\geq 61\%$ ), (2) minimum improvement in learning outcomes in the moderate N-Gain category ( $\geq 0.30$ ), and (3) minimum user response in the "Good" category ( $\geq 61\%$ ). If these three aspects are met, the EV KIT is declared feasible and effective as a learning medium for electric vehicles at PVTO Ahmad Dahlan University.

## RESULT AND DISCUSSION

The development of the Electric Vehicle Kit (EV-KIT) was carried out through five stages of the ADDIE model to produce a final product ready for implementation in learning. The validation results from three validators consisting of material experts, media experts, and industry practitioners showed that the EV-KIT met the feasibility criteria with an average score of 88.4%, included in the "Very Feasible" category. The validators provided notes on improvements in aspects of cable layout, electrical current safety, and the completeness of the learning module guide. After revisions were made based on the input, the EV-KIT was declared suitable for testing in the UAD PVTO learning environment.

### 1. Limited Trial Results

A limited trial was conducted on six students to assess the clarity of the instructions, safety of use, and ease of operation of the EV-KIT. Observation results showed that students were able to understand the relationship between components and the working principles of the electric vehicle system well. Student responses to the EV-KIT reached an average of 84.2%, which is categorized as "Very Good". Based on the pre-test and post-test results, there was an increase in the average score from 58.3 to 83.7, with an N-Gain value of 0.61 (moderate category). These results indicate that the EV-KIT is effective for use on a small scale to improve understanding of the basic concepts of electric vehicles.

## 2. Expanded Trial Results

An expanded trial was conducted on 19 students taking the Electric Vehicle Technology course. Students were divided into small groups and asked to assemble, test systems, and analyze experimental results using the EV-KIT. The pre-test results showed an average initial score of 60.5 for students, while the post-test score increased to 87.1. Based on the N-Gain calculation, the average score was 0.68, which falls into the "Moderate approaching high" category. This indicates a significant increase in students' knowledge competency after using the EV-KIT in the learning process.

## 3. User Response to EV-KIT

Student responses to the use of the EV-KIT were measured through a questionnaire covering three aspects: ease of use, attractiveness, and usefulness in learning. The average questionnaire result in the expanded trial showed a score of 86.7%, which is categorized as "Very Good." Students stated that the EV-KIT facilitated understanding of the concept of electric vehicle electrical systems, increased learning motivation, and made practicums more interesting and relevant to the modern automotive industry. Furthermore, the lecturer also gave positive feedback because this media helped visualize theoretical concepts more concretely.

## 4. Comparison of Limited and Expanded Trial Results

A comparison of the results of the two trials showed improvements in both learning outcomes and user response. A summary of the results can be seen in Table 1 below.

Table 1. Comparison of Limited Test Results and Expanded Test Results

Rated aspect		Limited Test (6 Students)	Expanded Test (19 Students)	Category
Average Score	Pre-test	58.3	60.5	-
Post-test Score	Average	83.7	87.1	-
<i>N-Gain</i>		0.61	0.68	Medium – High
Student Response (%)		84.2	86.7	Very good
Expert Eligibility (%)		88.4	88.4 (average)	Very Worthy

The table shows that both limited and expanded testing showed significant improvements in student learning outcomes. This improvement reinforces the finding that using the EV-KIT provides a more interactive, practical, and understandable learning experience.

## 5. Learning Effectiveness Analysis

The paired sample t-test analysis showed a significant value ( $p < 0.05$ ), indicating a significant difference between the pre-test and post-test results after implementing the EV-KIT. This means that the use of this media significantly improved students'

understanding of electric vehicle systems. In addition to improving academic grades, observations during the practicum showed increased active participation, collaboration skills, and skills in analyzing technical problems. This indicates that the EV-KIT not only improves knowledge but also strengthens students' vocational skills.

The implementation of the Electric Vehicle Kit (EV-KIT) significantly improved students' knowledge of the components and operation of electric vehicles. The increase in the average learning outcome score from pre-test to post-test and the N-Gain score of 0.65 (medium-high category) indicated that learning with the EV-KIT provided a more concrete learning experience. Students not only understood the basic concepts of electricity and energy, but were also able to explain the functions and interrelationships between components such as batteries, electric motors, controllers, power converters, and charging systems. These results align with research by Lie et al. (2025) who found that the use of the Electric Motorcycle Trainer Kit significantly improved students' understanding of the main components and flow of electric vehicle power systems because it provided a structured and safe, hands-on learning experience (W. Li et al., 2020).

From observations during the practical activities, students demonstrated improved ability to identify and explain how each part of the electric vehicle power system works (G. Li et al., 2014; Rahim et al., 2020). For example, students were able to explain that the battery functions as the main energy storage, the electric motor plays a role in converting electrical energy into mechanical energy, and the controller regulates the electrical current entering the motor so that the vehicle can move efficiently (Achmadi et al., 2023; Kesler et al., 2022). This understanding was reinforced through direct experiments with the EV-KIT, which allowed students to observe energy flow, voltage changes, and the system's response to changes in load. According to Achmadi et al. (2023), training kit-based practice improves students' analytical skills and relational understanding of electrical system concepts because they can directly see the interconnections between components in realistic scenarios (Achmadi et al., 2023).

Expert validation of the EV-KIT indicates that this tool is suitable for use in learning electric vehicle systems with an average score of 88.4% (very suitable category). This feasibility includes technical aspects, safety, material suitability, and ease of use. According to Ramirez et al. (2022), learning media developed based on the principles of engineering education design must be able to present a connection between theory and practice so that students understand the mechanism of the component system in depth (Curiel-Ramirez et al., 2022). In this context, the EV-KIT has fulfilled this principle by presenting a working model of an electric vehicle that is easy to observe, measurable, and repeatable (replicable learning cycle).

In addition to enhancing cognitive aspects, learning with the EV-KIT also strengthens students' psychomotor skills in terms of system assembly, testing, and circuit error analysis (Shafieek et al., 2024). Students are trained to recognize symptoms of current imbalance, measure voltage, and observe motor responses to variations in power input (Ravi et al., 2024). These findings support the research results of Tremblay et al. (2016) which showed that electro-pneumatic training kits significantly improve technical skills and diagnostic abilities of industrial control systems. Thus, the EV-KIT not only improves students' conceptual understanding of electric vehicles but also builds essential technical skills for future job readiness in the automotive sector (Tremblay et al., 2016).

The student response rate of 86.7% (very good) indicates that they considered the EV-KIT easy to use, engaging, and relevant to the needs of modern automotive learning. Students stated that using the EV-KIT made it easier for them to understand the workflow of electric vehicle power systems, which were previously difficult to understand through theoretical explanations (Ravi et al., 2024). This is consistent with the research findings of Safiek (2024), who found that learning media based on automotive electrical systems increased student motivation and knowledge retention because it provided direct

visualization from theory to practice. With hands-on experience, students were able to develop systematic thinking skills in analyzing how each component works as a whole electric vehicle system (Shafieek et al., 2024).

Learning using the EV-KIT also supports the Project-Based Learning (PjBL) approach, which positions students as active participants in the learning process. Through EV-KIT assembly and testing projects, students experience an exploration process that integrates concepts from physics (energy and force), electronics (current and voltage), and mechanics (transmission and torque) within the context of electric vehicles (Ghozali et al., 2023). This approach aligns with the STEM (Science, Technology, Engineering, and Mathematics)-based vocational education paradigm, which emphasizes interdisciplinary integration (Surti et al., 2022). Research by Wang et al. (2020) demonstrated that the application of STEM-integrated projects in vocational education can enhance understanding of complex automotive system concepts, including electric and hybrid vehicle systems. Therefore, the EV-KIT serves not only as a learning tool but also as a means of implementing cross-disciplinary learning relevant to the needs of today's automotive industry (Wang et al., 2020).

In terms of learning effectiveness, the results of the paired sample t-test showed that the increase in student learning outcomes was statistically significant ( $p < 0.05$ ), indicating that the EV-KIT effectively increased students' understanding of how electric vehicles work (Hamid et al., 2020). This improvement indicates that students can understand how electric current flows from the battery to the controller, how the energy conversion system is regulated, and how the regenerative braking mechanism functions. According to Khodaparastan et al. (2019), a systematic understanding of the energy flow and control of electric vehicles is an important foundation for prospective vocational workers to keep up with developments in the electrification-based automotive industry. Thus, the EV-KIT plays a crucial role as a transformative medium in shaping students' basic competencies in future vehicle technology (Khodaparastan et al., 2019).

Overall, the results of this study confirm that the development and implementation of the EV-KIT are effective in improving students' knowledge of the components and workings of electric vehicles through contextual, safe, and efficient practical learning. This is consistent with various recent studies such as Xiaobo et al. (2025), Ghozali et al. (2023), and Koohfar et al. (2023) which confirm the effectiveness of vocational practice media in developing an understanding of modern electrical systems. With a hands-on practice-based approach and integrated projects, the EV-KIT can be a relevant learning innovation to strengthen the technological competence of vocational students in the transition era towards electric vehicles (Qu et al., 2020)(Ghozali et al., 2023)(Koohfar et al., 2023).

## **CONCLUSION**

This study concludes that the implementation of the Electric Vehicle Kit (EV-KIT) has proven effective in improving students' knowledge competency regarding the components and workings of electric vehicles in the Automotive Technology Vocational Education Study Program at Ahmad Dahlan University. The results of the study showed an increase in the average value of student learning outcomes with an N-Gain value of 0.65 (medium-high category) and a user response of 86.7% (very good category), which indicates that students can concretely understand the functions and relationships between main components such as batteries, electric motors, controllers, and charging systems. The impact of the EV-KIT implementation is seen in the improvement of system analysis skills, automotive electrical practical skills, and student learning motivation towards electric vehicle technology. This media is also considered practical, safe, and relevant to the development of the electrification-based automotive industry, thus having the potential to become a strategic innovation in modern vocational learning. Recommendations proposed include the widespread implementation of the EV-KIT in the

automotive curriculum, lecturer training to optimize project-based learning, and collaboration between universities and industry in developing an advanced version of the EV-KIT integrated with digital technology and a battery management system, to support students' readiness to face the era of electric vehicles in the future.

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