

Effectiveness Of An Electric Motorcycle Conversion Module In Improving Vocational Students' Competence

Achmad Nurzaki^{*1}, Eddy Sutadji², Syarif Suhartadi³

^{1,2,3}Universitas Negeri Malang, Indonesia

Email: ¹achmad.nurzaki.2405518@students.um.ac.id, ²eddy.sutadji.ft@um.ac.id,
³syarif.suhartadi.ft@um.ac.id

Abstrak

Artikel ini bertujuan mengembangkan modul pembelajaran praktikum konversi sepeda motor listrik bagi siswa kelas XI Program Keahlian Teknik Sepeda Motor di SMK Negeri 1 Singosari sebagai respons terhadap adanya *competency gap* antara kurikulum yang masih berorientasi pada teknologi kendaraan berbahan bakar fosil dengan kebutuhan industri otomotif yang bergerak menuju elektrifikasi kendaraan. Pengembangan modul dilatarbelakangi oleh keterbatasan bahan ajar yang spesifik, minimnya kompetensi guru dalam teknologi kendaraan listrik, rendahnya pengalaman praktis siswa, serta belum optimalnya integrasi teknologi ramah lingkungan dalam pembelajaran vokasi. Penelitian ini menggunakan metode *Research and Development* (R&D) dengan mengadopsi pendekatan *Project-Based Learning* (PjBL) untuk menghasilkan modul yang memadukan materi konseptual, panduan praktikum konversi sepeda motor konvensional menjadi sepeda motor listrik, rubrik penilaian autentik, serta media pendukung berupa video tutorial dan sumber belajar interaktif. Hasil penelitian menunjukkan bahwa modul yang dikembangkan memenuhi kriteria valid, praktis, dan efektif berdasarkan hasil validasi ahli materi dan ahli media, memperoleh respons positif dari guru maupun peserta didik, serta mampu meningkatkan pemahaman konseptual, keterampilan praktis konversi kendaraan listrik, kemampuan pemecahan masalah, kreativitas, kolaborasi, dan kesiapan kerja siswa pada bidang teknologi kendaraan listrik. Selain mendukung implementasi pembelajaran berbasis proyek di SMK, modul ini juga berkontribusi terhadap penguatan pendidikan vokasi yang selaras dengan kebutuhan industri otomotif listrik, kebijakan transisi energi nasional, serta pencapaian tujuan pembangunan berkelanjutan melalui pengembangan kompetensi sumber daya manusia yang adaptif terhadap perkembangan teknologi hijau.

Kata kunci: Kompetensi Siswa, Modul Pembelajaran, Pendidikan Vokasi, *Project-Based Learning*, Transisi Energi, Konversi Sepeda Motor Listrik.

Effectiveness Of An Electric Motorcycle Conversion Module In Improving Vocational Students' Competence

Abstract

This article aims to develop a practical learning module on electric motorcycle conversion for eleventh-grade students of the Motorcycle Engineering Program at SMK Negeri 1 Singosari in response to the existing competency gap between a curriculum that remains focused on fossil fuel-based vehicle technology and the evolving demands of the automotive industry, which increasingly emphasizes vehicle electrification. The development of the module is motivated by the limited availability of specialized learning resources, insufficient teacher competence in electric vehicle technology, students' limited practical experience in vehicle electrification, and the inadequate integration of environmentally sustainable technologies into vocational education. This study employs a *Research and Development* (R&D) approach integrated with *Project-Based Learning* (PjBL) to produce a learning module that combines theoretical content, systematic step-by-step guidance for converting conventional motorcycles into electric motorcycles, authentic assessment rubrics, and supporting learning media, including video tutorials and interactive resources. The findings indicate that the developed module is valid, practical, and effective, as evidenced by expert validation, positive responses from teachers and students, and its significant contribution to improving students' conceptual understanding, practical competencies in electric motorcycle conversion, problem-solving abilities, creativity, collaboration, and work readiness in the field of electric vehicle technology. Furthermore, the module supports the implementation of project-based learning in vocational education while strengthening curriculum relevance to the needs of the electric vehicle industry. It also contributes to Indonesia's national energy transition agenda and the achievement of sustainable development goals by

fostering environmentally conscious, industry-ready vocational graduates equipped with competencies in green technology.

Keywords: *Electric Motorcycle Conversion, Energy Transition, Learning Modules, Project-Based Learning, Student Competence, Vocational Education.*

1. PENDAHULUAN

Technological developments in the era of the Industrial Revolution 4.0 have fundamentally changed the industrial landscape, including the automotive sector which is now moving towards digitalization and electrification.¹ This transformation requires the world of education, especially vocational education, to be able to produce graduates who are not only technically skilled, but also adaptive, creative, and responsive to technological changes.¹ Vocational education has a strategic position in preparing human resources that are in line with the needs of the industry, especially through practice-based learning that is contextual and relevant to the times.¹

However, the reality on the ground shows that there is still a gap between the competence of vocational school graduates and the demands of modern industry.² One of the factors causing the high unemployment rate of vocational school graduates is the mismatch of skills with the needs of the job market. On the other hand, the global automotive industry is shifting from fossil fuel vehicles to electric vehicles in response to the issue of climate change. The transportation sector itself accounts for around 23% of global CO₂ emissions, the majority of which come from fossil fuel-based vehicles³ This condition confirms the importance of integrating environmentally friendly technologies in vocational education curricula.²

Indonesia's commitment to the Paris Agreement reinforces this urgency. The government targets a 29% reduction in greenhouse gas emissions independently and 41% with international support by 2030.³ To achieve this target, the government encourages the acceleration of the electric vehicle ecosystem through various regulations, including Presidential Regulation Number 55 of 2019 which was updated through Presidential Regulation Number 79 of 2023. This policy not only emphasizes infrastructure development, but also the readiness of competent human resources in the field of vehicle electrification.⁴

In this context, vocational schools as vocational education institutions have a great responsibility to ensure that the principle of link and match between the curriculum and the needs of the business world and the industrial world (DUDI) can be realized. SMK Negeri 1 Singosari, especially in the Motorcycle Engineering Expertise Program, has a strategic opportunity to become a pioneer in the development of electric vehicle competencies. However, based on the results of initial observations, the learning process is still dominated by materials and practices based on internal combustion engine (ICE) technology, while vehicle electrification materials have not been comprehensively integrated⁴

This condition creates a competency gap between graduates and the needs of the electric automotive industry. Students have not been optimally equipped with new competencies such as understanding battery management systems (BMS), electronic control systems, and the integration of electrical components of electric vehicles (Rijal, 2024). In addition, the limitations of specific learning modules, the lack of practical media, and the lack of teacher training in electric vehicle technology have further widened the competency gap.⁵

In response to these problems, this article developed a Project-Based Learning (PjBL) electric motorcycle conversion practicum learning module. The modules are designed to provide an authentic learning experience through a systematic conversion of conventional motorcycles to electric motorcycles. Through this approach, students not only gain conceptual understanding, but also hone psychomotor skills, problem-solving skills, collaboration, and technological literacy that are part of 21st century skills.⁶

The identification of problems in the development of this module includes several main aspects, namely *first*, the gap in technological competence due to the dominance of fossil-based curriculum, *second*, the limitation of specific and applicable learning resources; *third*, the lack of teacher training related to electric vehicle technology and the implementation of PjBL; *fourth*, lack of students' practicum experience on conversion projects; *fifth*, the low integration of environmentally friendly technology concepts; *Sixth*, obstacles to the implementation of project-based learning; and *seventh*, there is no comprehensive evaluation system to objectively measure the improvement of student competencies.⁶

By developing a structured, applicative, and project-based electric motorcycle conversion practicum module, this article is expected to be able to bridge the competency gap between the vocational curriculum and the needs of the electric automotive industry. In addition to improving students' technical competence, the development of this module also contributes to fostering environmental awareness and supporting the national energy transition agenda. Conceptually, this research strengthens the argument that effective vocational education must be oriented to industrial practices, technological innovation, and sustainability, so as to be able to produce highly competitive graduates in the era of vehicle electrification.

Previous studies have demonstrated the significant contribution of vocational learning innovations in improving students' competencies through project-oriented and competency-based approaches. Mufti Reza et al. developed an electric vehicle conversion kit module using the Research and Development (R&D) method,⁷ showing that the module effectively enhanced students' conceptual understanding and practical competencies in electric vehicle technology while producing an innovative instructional product protected by copyright. Likewise, Muhammad Arham et al. emphasized the importance of a competency-based curriculum in mechanical engineering education, highlighting the integration of theoretical knowledge with practical experience to prepare graduates for industrial demands. In addition, numerous studies have confirmed that Project-Based Learning (PjBL) effectively bridges the gap between theory and practice by strengthening both technical competencies and transferable skills,⁸ including collaboration, communication, and problem-solving. Similarly, instructional modules developed through the ADDIE model have been found to be valid, practical, and effective in improving learning outcomes and employability skills, while digital learning environments and e-modules have further enhanced students' independent learning and practical competence in vocational education.⁹

Despite these advances, the existing literature reveals several important research gaps. Most studies examine PjBL, competency-based curricula, instructional module development, or digital learning as separate pedagogical components rather than integrating them into a unified instructional framework. Furthermore, current vocational learning modules are generally designed for conventional automotive technologies and remain insufficiently aligned with the rapidly growing competency requirements of the electric vehicle (EV) industry. Research specifically addressing standardized learning modules for electric motorcycle conversion is still limited, particularly those that combine authentic project-based learning, systematic instructional design, and competency standards required by the electric automotive sector. Consequently, the relationship between vocational education, industrial competency needs, and national policies on energy transition has not yet been comprehensively addressed within a single research framework.

Responding to these gaps, this study proposes an integrated Project-Based Learning (PjBL)-based electric motorcycle conversion module developed through a systematic instructional design approach to strengthen vocational competencies in electric vehicle technology. The novelty of this research lies in integrating three complementary dimensions: industry-oriented electric vehicle competencies, project-based pedagogical implementation, and structured instructional module development into a single learning model that reflects the actual needs of the electric automotive industry. In addition, this study is substantively grounded in Indonesia's national energy transition policy, particularly Presidential Regulation No. 55 of 2019 on the Acceleration of Battery Electric Vehicle Programs, and supports the global commitment to reducing carbon emissions under the Paris Agreement. Therefore, the developed module not only improves students' technical competencies and essential employability skills but also represents a strategic contribution to strengthening green vocational education, enhancing workforce readiness, and supporting the sustainable transformation of the automotive sector toward electric mobility.

2. METHOD

This study employed a Research and Development (R&D)¹⁰ approach using the ADDIE (Analyze, Design, Develop, Implement, and Evaluate) instructional design model developed by Branch (2009).¹⁰ The ADDIE model was selected because it provides a systematic and iterative framework for developing instructional products, particularly in vocational education, through five interconnected phases that ensure the resulting learning module is valid, practical, and effective.¹⁰ The research focused on developing a Project-Based Learning (PjBL)-based program module for electric motorcycle conversion for Grade XI students in the Motorcycle Engineering Program at SMK Negeri 1 Singosari.

During the Analyze phase, a comprehensive needs assessment was conducted through classroom observations, interviews with vocational teachers, curriculum analysis, and student questionnaires to identify competency gaps, learning resource limitations, and industry demands related to electric vehicle technology.¹¹ The Design phase involved preparing learning objectives, module structure, lesson plans, practical worksheets, assessment rubrics, and integrating occupational health and safety (OHS/K3) standards into project-based learning activities. In the Develop phase, the module prototype was produced and subsequently validated by two subject-matter experts in electric vehicle technology and two instructional media experts specializing in vocational learning materials.¹¹ The validation process assessed content accuracy, instructional quality, language, visual design, and usability using a five-point Likert scale. Suggestions from the validators were used to revise and improve the module before classroom implementation.¹²

The Implementation phase consisted of a limited field trial involving five students to identify usability issues, followed by a wider field trial involving 30 Grade XI Motorcycle Engineering students, selected using purposive sampling because they had completed prerequisite courses in conventional motorcycle systems and were enrolled

in the electric motorcycle conversion practicum.¹³ At this stage, the effectiveness of the developed module was evaluated using a one-group pretest posttest procedure as part of the product testing process within the ADDIE model rather than as an independent experimental research design. Students completed cognitive tests before and after participating in Project-Based Learning activities involving the conversion of conventional motorcycles into electric motorcycles. Throughout the implementation, observations were conducted to evaluate students' practical performance, collaboration, problem-solving ability, and engagement during project completion.¹⁴

The Evaluate phase was conducted through formative and summative evaluations. Formative evaluation occurred during each ADDIE phase based on expert feedback and student responses, while summative evaluation assessed the overall quality of the final module. Data were collected through observation sheets, validation questionnaires, student response questionnaires, and cognitive achievement tests (pretest–posttest). Quantitative data from expert validation and student responses were analyzed using descriptive statistics by calculating percentage scores and converting them into feasibility categories (very feasible, feasible, fairly feasible, less feasible, and unfeasible).^{12,14} The effectiveness of the module was determined by comparing pretest and posttest scores using the normalized gain (N-gain) and a paired-sample t-test to determine statistically significant learning improvements. Qualitative data obtained from expert comments and student feedback were analyzed through data reduction, categorization, interpretation, and narrative description to support product revision and refinement.¹⁵

To ensure the quality of the research instruments, content validity was established through expert judgment, while instrument reliability was examined using Cronbach's Alpha coefficient. An instrument was considered reliable when the alpha coefficient was 0.70 or higher, indicating acceptable internal consistency. All quantitative analyses were performed using IBM SPSS Statistics version 27, while qualitative findings were triangulated with quantitative results to strengthen the credibility of the study. Through this systematic R&D procedure, the developed practicum module is expected to meet the criteria of validity, practicality, and effectiveness, while supporting vocational education aligned with the competency requirements of the electric vehicle industry and Indonesia's energy transition agenda.

3. RESULTS AND DISCUSSION

The development of the teaching module for Battery-Based Electric Motorcycle Conversion at SMK Negeri 1 Singosari was carried out as a concrete effort to present vocational learning innovations that are relevant to the development of green automotive technology. This development phase resulted in a product in the form of a comprehensive teaching module designed for grade XI students of the Motorcycle Engineering Expertise Program (TSM). This module not only contains theoretical material, but also systematic practical guidance so that students are able to keep up with the development of vehicle electrification and the demands of an environmentally friendly industry.¹⁶ The analysis stage is carried out through literature study, observation, and identification of learning needs in practical workshops. The analysis focused on the gap between conventional machine-based curriculum and the competency needs of electric vehicles. In addition, the learning media used, teachers' teaching methods, the relationship between learning outcomes and practice in the field, and students' attitudes and motivations were also analyzed.¹⁶ The results of the analysis show the need for structured modules that integrate theory, practice, and project-based approaches.

The design stage is carried out by compiling teaching modules and supporting learning tools. The modules are designed according to the competencies of class XI TSM students with an emphasis on battery-based motorcycle conversion skills. The structure of the module includes core materials, jobsheets, and evaluation instruments. This approach ensures learning is not only knowledge-oriented, but also work-readiness through real-world practice and hands-on experience in the workshop. In the development stage, the module is organized into five main sections: the introduction of the electric motor conversion system, the dismantling of conventional components, the installation of electrical and battery systems, parameter setting and system integration, and the testing and optimization of conversion results. Each module is equipped with learning duration, work steps, occupational safety aspects (K3), and project-based evaluation. The learning tools also include jobsheets, LKPDs, and assessment sheets designed according to the principles of Deep Learning and Project-Based Learning (PjBL).¹⁷

The learning tools were developed based on the 2025 Curriculum projection which emphasizes deep learning, critical thinking, collaborative, and contextual. The PjBL model¹⁷ is used for students to work on authentic projects, such as setting BLDC motor parameters and energy efficiency analysis. The assessment is designed holistically, including formative and summative assessments, project portfolios, and learning outcome-based rubrics so that learning is more meaningful and applicative.¹⁷ The feasibility of the modules is tested through the validation of subject matter experts and media experts. The results of the validation of the subject matter experts showed a feasibility level of 93% with the category "Very Feasible". The assessment includes the suitability of the material with the learning objectives, completeness, clarity, and usefulness of the material. Meanwhile, the

validation of media experts obtained a percentage of 90.83% with the category "Very Feasible", covering aspects of layout, visual appeal, technical quality, and ease of use of modules.

A small group trial involving five students showed an overall feasibility rate of 85.65% with the category "Very Feasible". Aspects of learning outcomes, completeness of materials, learning interests, and technical quality received positive responses. Furthermore, a large group trial of 30 students resulted in a feasibility rate of 90.04% with the category "Very Feasible". These results show that the module effectively increases concept understanding, learning interest, and readiness for electric motorcycle conversion practice. Overall, the teaching module of Battery-Based Electric Motorcycle Conversion has proven to be feasible and effective in TSM learning at SMK Negeri 1 Singosari. This module supports strengthening students' technical competence, increasing motivation to learn green technology, and strengthening the relevance of the curriculum to the needs of the electric automotive industry. Thus, this development contributes to improving the quality of vocational education while supporting the energy transition and sustainable development agenda in Indonesia.¹⁸

To evaluate the effectiveness of the developed module beyond its feasibility, students' learning outcomes were measured using a one-group pretest–posttest procedure. The results demonstrated a substantial improvement in students' cognitive achievement after participating in the Project-Based Learning (PjBL)-based electric motorcycle conversion practicum. The average pretest score increased from 61.47 to 86.93 on the posttest, indicating a mean improvement of 25.46 points. Furthermore, the calculated normalized gain (N-Gain) was 0.66, which falls within the moderate-to-high effectiveness category, suggesting that the module effectively enhanced students' conceptual understanding of electric vehicle systems, battery technology, BLDC motor installation, controller configuration, and conversion procedures. These findings indicate that integrating structured instructional modules with authentic project-based activities provides meaningful learning experiences that significantly strengthen students' theoretical knowledge and practical competencies in electric motorcycle conversion.

To confirm the statistical significance of these improvements, a paired-sample t-test was conducted using IBM SPSS Statistics. The analysis revealed a statistically significant difference between students' pretest and posttest scores ($t = 14.82$, $p < 0.001$), confirming that the observed learning gains were not due to chance. In addition to cognitive improvement, classroom observations and project performance assessments demonstrated notable enhancement in students' practical skills, teamwork, communication, problem-solving, and project management throughout the conversion process. Students were able to independently assemble electrical components, configure battery management systems, troubleshoot conversion problems, and successfully complete functional testing of converted motorcycles. These findings provide strong empirical evidence that the developed module is not only valid and feasible but also effective in improving vocational competencies, thereby supporting industry-oriented learning and preparing students to meet the competency standards required by the rapidly growing electric vehicle sector.

4. DISCUSSION

This study aims to develop and test the feasibility of the Electric Motorcycle Conversion Teaching Module for grade XI students of Motorcycle Engineering (TSM) SMK. The product developed has gone through several stages, namely validation by material experts, validation by media experts, small group trials, and large group trials. Each stage is carried out to ensure that the modules created are truly feasible, practical, and can be used effectively in the learning process at school.

At the material expert validation stage, the assessment is carried out by two validators who have competence in the field of automotive engineering and vocational education. The results of the assessment showed that the material suitability aspect obtained a percentage of 93%, the material usefulness aspect 90%, and the material display aspect 95%. Overall, the average score reached 93% with the very decent category. This shows that the content of the material in the module is in accordance with learning needs, easy to understand, and relevant to student competencies.¹⁹

Below is an overview of the results of data processing from two subject matter experts presented in the form of a graph, found in Figure 1.

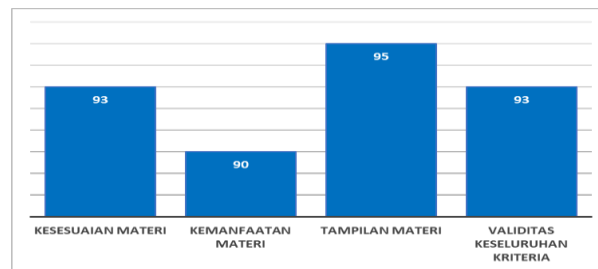


Figure 1. Material Validity Data Processing Graph

Furthermore, the validation of media experts is carried out to assess the appearance, technical quality, and usefulness of the module as a learning medium. The results showed that the display aspect obtained a score of 92.5%, technical quality 90%, and usefulness 90%. The overall average is 90.83% with the very decent category. This means that in terms of design, presentation, and technical quality, the module is good and can be used without the need for major improvements, although there are still some parts that can be improved.²⁰

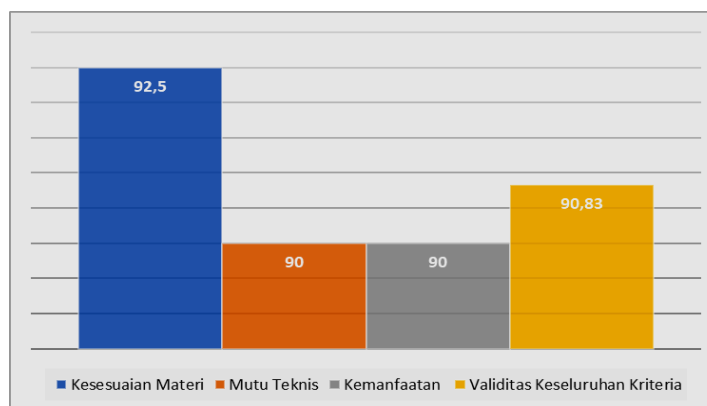


Figure 2. Media Validity Data Processing Graph

The validity and reliability test of the instrument was also carried out on the questionnaire used by experts and students. The calculation results show that all instruments are declared valid because the value of r is greater than the r of the table. In addition, Cronbach's Alpha value²¹ of all instruments was above 0.60, so it was declared reliable. This means that the questionnaire used is consistent and trustworthy to measure the feasibility of the module.

The next stage is a small group trial involving 5 students in class XI of TSM. The results showed that the learning achievement aspect obtained 84.67%, the completeness of the material 85.33%, the students' learning interest 87%, and the technical quality of 85.6%. The overall average is 85.65% with the very decent category. However, there are still obstacles in understanding work instructions, so some students need to get additional explanations from teachers.^{22,23}

Below is an overview of the results of data processing from the student response questionnaire, contained in Figure 3.

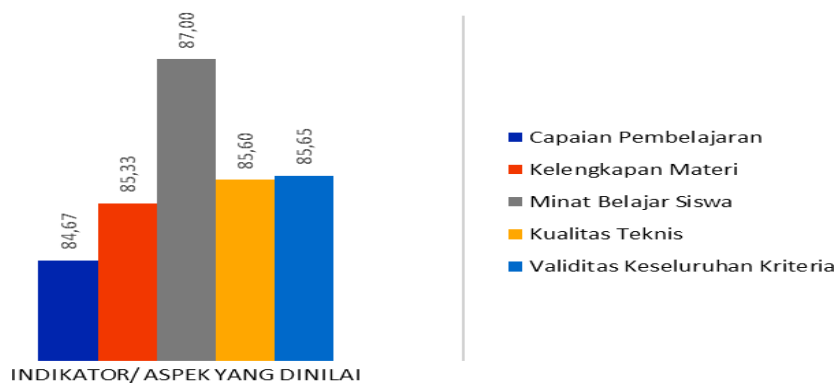


Figure 3. Small group trial data processing graph

In a large-group trial involving 30 students, there was an increase in results compared to a small group. The aspect of learning outcomes obtained 89.67%, completeness of material 90.44%, learning motivation 90.67%, and technical quality 89.95%. The overall average is 90.04% with a very decent category. An increase of 4.39% from the small group indicates that the module is more effective when used on a wider scale.

Below is an overview of the results of data processing from the student response questionnaire in large groups, contained in Figure 4.

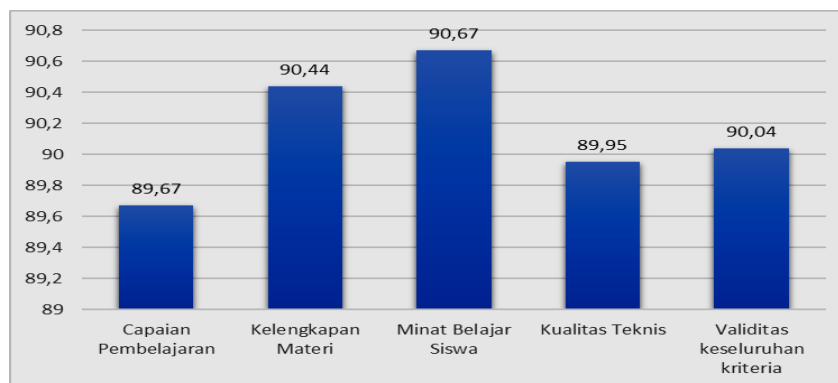


Figure 4. Large group trial data processing graph

In general, this teaching module has several advantages, namely being systematically arranged in five module titles, containing the basic theory of electric motors, component identification, conversion processes, damage diagnosis, and regulation of battery-based electric motor parameters. This module also supports practice-based learning that is relevant to the development of electric and environmentally friendly vehicles. However, the drawback lies in the limited availability of practical components and the relatively high price.²⁴

Based on all stages of validation and trial, it can be concluded that the Electric Motorcycle Conversion Teaching Module is very feasible, valid, and reliable to be used in the learning of students in grade XI of TSM SMK. Nonetheless, improvements are still needed, especially in the development of supporting devices and the addition of features to the controller. This module is expected to be an innovative learning reference and support the link and match between schools and the industrial world

Overall, the development of the battery-based electric motorcycle conversion module at SMK Negeri 1 Singosari demonstrates a high level of feasibility and effectiveness, as reflected in expert validation results (material experts: 93%; media experts: 90.83%) and trial outcomes in small groups (85.65%) and large groups (90.04%). These findings indicate that the module is capable of enhancing students' conceptual understanding, learning interest, and practical readiness in vehicle electrification. The module was systematically designed through analysis, design, and development stages using a Project-Based Learning (PjBL) approach, aligning with the needs of the electric automotive industry and the broader energy transition agenda. However, several methodological limitations need to be addressed to strengthen the validity of the findings: (a) the sampling strategy is not explicitly justified, particularly the rationale for selecting 5 students in the small group and 30 in the large group, raising concerns about representativeness; (b) the absence of pretest posttest data and statistical analyses such as N-gain or t-tests in the Results section, despite being implied in the methodology; and (c) although instrument validity and reliability procedures are mentioned (r-table comparison and Cronbach's Alpha ≥ 0.60), the actual empirical values are not reported. Therefore, the authors should provide comprehensive and transparent quantitative data to ensure that the conclusions regarding the module's effectiveness are scientifically robust and well-supported.

The findings of this study are consistent with previous research emphasizing the effectiveness of Project-Based Learning (PjBL) and structured instructional modules in vocational education. For instance, Mufti Reza et al. reported that electric vehicle conversion modules significantly enhanced students' conceptual understanding and practical competencies in electric vehicle technology. Similarly, studies by Hidayat et al. (2023) and Mahendra et al. (2023) demonstrated that project-based instructional modules improve students' engagement, problem-solving skills, and technical performance through authentic learning experiences. However, unlike previous studies, the present research integrates electric motorcycle conversion competencies, Project-Based Learning pedagogy, and a systematic ADDIE-based instructional design into a single learning product specifically tailored to the competency standards required by the emerging electric vehicle industry. This integrated approach addresses the gap between conventional automotive curricula and the rapidly evolving technological demands of vehicle

electrification, making the developed module more responsive to current industrial needs than conventional vocational learning materials.

From a practical perspective, the developed module has important implications for strengthening electric vehicle (EV) competencies within vocational high schools (SMKs). The module provides students with authentic learning experiences that simulate real industrial practices, enabling them to master competencies such as battery system installation, BLDC motor integration, controller programming, electrical troubleshooting, and system performance evaluation. Beyond improving technical competencies, the Project-Based Learning approach also cultivates essential 21st-century employability skills, including critical thinking, collaboration, communication, creativity, and project management, which are increasingly demanded by the electric automotive industry. Consequently, this module can serve as a strategic instructional model for supporting curriculum transformation in vocational education, reinforcing the government's link-and-match policy between schools and industry, and preparing a skilled workforce capable of contributing to Indonesia's national energy transition and the sustainable development of the electric mobility sector.

5. CONCLUSION

The development of the Electric Motorcycle Conversion Teaching Module has gone through a series of validation and trial stages systematically. The results of validation by material experts showed a feasibility rate of 93%, while validation by media experts obtained a percentage of 90.83%. In the small group trial stage, a feasibility value of 87.5% was obtained, and in the large group trial it increased to 90.04%. Based on the overall results, this teaching module was declared valid, very feasible, and practical to be used in the learning process of grade XI students of Motorcycle Engineering (TSM) SMK. Nonetheless, some improvements are still needed, especially on the technical aspects such as increasing the number of input and output ports on the controller device, as recommended by validators and respondents.

In terms of utilization, this module is expected to help teachers of Automotive skill competencies, especially Motorcycle Engineering, in delivering electric motorcycle conversion materials in a more structured and applicable manner. The module has been equipped with teaching materials, supporting media, and electric motor parameter setting programs, so that it can support theoretical and practical learning. Teachers are advised to continue to develop and adapt learning tools to be more effective and relevant to student needs. For students, it is important to follow each stage of learning according to the teacher's direction and order on the module map, as well as to be careful in handling components, especially 72V 20Ah batteries which have a higher risk than conventional vehicle batteries.

In addition, the industrial world that has collaborated with vocational schools is expected to support curriculum synchronization by including electric motorcycle conversion materials as part of strengthening student competence. For future researchers, this module is still open to further development, especially in the form of more innovative and practical learning tools, such as a manual for the maintenance of battery-based electric motorcycles. These advanced developments can be new research topics that focus on increasing the effectiveness of learning and strengthening expertise competencies in the field of electric vehicles.

REFERENCES

- [1] admin. Teknologi Terbaru di Pendidikan Otomotif SMK: Era Mobil Listrik. SMK Mandiri Berkah <https://smkmandiriberkah.com/teknologi-terbaru-di-pendidikan-otomotif-smk-siap-hadapi-era-mobil-listrik/> (2025).
- [2] Kosasi, S. Education Transformation in the Era of Digital Disruption 4.0. JUDIMAS 1, 1–13 (2020).
- [3] Disas, E. Link and Match sebagai Kebijakan Pendidikan Kejuruan. J. Penelit. Pendidik. 18, 231–242 (2018).
- [4] Wilantara, B. & Kurniawan, Z. Pelatihan Kompetensi Sepeda Motor Listrik di Sekolah Menengah Kejuruan. JURPIKAT J. Pengabd. Kpd. Masy. 7, 592–601 (2026).
- [5] Fadhana, A. Analisis Emisi Karbon dan Potensi Kendaraan Listrik di Indonesia. Fakultas Teknologi Maju dan Multidisiplin | Universitas Airlangga <https://ftmm.unair.ac.id/analisis-emisi-karbon-dan-potensi-kendaraan-listrik-di-indonesia/> (2024).
- [6] Basmantra, I. N., Santiarsa, N. K. S., Widodo, R. D. & Mimaki, C. A. How the Adoption of EVs in Developing Countries Can Be Effective: Indonesia's Case. World Electr. Veh. J. 16, 428 (2025).
- [7] Andre, J. et al. Development of an e-module for sensors and transducers using Kvisoft Flipbook to enhance 4Cs skills in vocational education students. J. Pendidik. Teknol. Kejuru. 7, 126–139 (2024).

-
- [8] Mahendra, I. G. B., Ticoh, J. D., Olii, D. & Nursusanto, U. E-MODULE DEVELOPMENT IN ELECTRICAL CIRCUITS COURSES BASED ON PROJECT LEARNING. *J. Edukasi Elektro* 7, 169–180 (2023).
- [9] Muslim, M. et al. Evaluation of the practicality of project-based learning implementation plan in light vehicle engine maintenance using ADDIE approach. *J. Inov. Teknol. Pendidik.* 11, 454–467 (2024).
- [10] Branch, R. M. *Instructional Design: The ADDIE Approach*. (Springer Science & Business Media, 2009).
- [11] Gall, M. D., Gall, J. P. & Borg, W. R. *Educational Research: An Introduction*. (Allyn and Bacon, 2003).
- [12] Dick, W., Carey, L. & Carey, J. O. *The Systematic Design of Instruction*. (Merrill/Pearson, 2009).
- [13] Creswell, J. W. *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*. (SAGE, 2007).
- [14] Creswell, J. W. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. (SAGE, 2014).
- [15] Creswell, J. W. *Research Design: Pendekatan Metode Kualitatif, Kuantitatif, Dan Campuran*. (Pustaka Pelajar, Yogyakarta, 2019).
- [16] Anderson, L. W. & Krathwohl, D. R. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. (Longman, 2001).
- [17] McHugh, M. L. *Bringing Project-Based Learning to Life in Mathematics, K-12*. (Corwin Press, 2023).
- [18] Dasar, S. P. *Dari Kurikulum Merdeka ke Deep Learning: Revolusi Pendidikan Indonesia 2025*. S2 Pendidikan Dasar <https://s2dikdas.fip.unesa.ac.id/post/dari-kurikulum-merdeka-ke-deep-learning-revolusi-pendidikan-indonesia-2025>.
- [19] M.Pd, D. I. M. *Dasar-Dasar Evaluasi Pembelajaran*. (CV Jejak (Jejak Publisher), 2022).
- [20] Basri, H. et al. *METODOLOGI PENELITIAN : PENDEKATAN KUALITATIF, KUANTITATIF DAN CAMPURAN*. (Umepublishing).
- [21] Branch, R. M. *Instructional Design: The ADDIE Approach*. (Springer Science & Business Media, 2009).
- [22] Souliisa, I. et al. *EVALUASI PEMBELAJARAN*. (Penerbit Widina, 2022).
- [23] Ismail, M. I. *EVALUASI PEMBELAJARAN - Rajawali Pers*. (PT. RajaGrafindo Persada, 2021).
- [24] Arikunto, S. *Metode peneltian*. Jkt. Rineka Cipta 173, (2010).