



Literature Review of the Utilization of Eco-Friendly Technology in Automotive Engineering Learning

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ABSTRACT

The growing demand for a sustainability-oriented automotive industry requires vocational high school (SMK) students to master environmentally friendly technologies. This study analyzes the implementation of green automotive technology in learning and identifies the media, methods, and supporting factors that strengthen students' green skills. Using a descriptive qualitative approach, the research collects primary data through interviews and observations with teachers and instructors, and secondary data from curriculum documents, teaching modules, and relevant literature. Data were examined using content and thematic analysis with source triangulation. The findings show that integrating Green TVET principles into the curriculum and laboratory activities, supported by digital modules, practical simulators, and electric vehicle conversion projects, effectively enhances students' conceptual understanding, practical competence, and environmental awareness. The Teaching Factory model strengthens experiential learning by providing industry-like environments that allow students to apply theory directly to practice. Teacher competence both technical and digital emerges as a key factor in successful implementation. Although challenges such as limited laboratory infrastructure and varied digital literacy remain, the adoption of environmentally friendly technologies offers significant opportunities to equip students with relevant green skills. Overall, this study demonstrates that embedding sustainability-based competencies in automotive engineering education can produce adaptive and competent graduates aligned with the future needs of the green automotive industry.

INTRODUCTION

Global developments towards the green economy and environmental sustainability have driven transformation in various sectors, including the automotive industry. The shift from fossil-fueled conventional vehicles to

electric vehicles, vehicle conversion, and environmentally friendly automotive practices require the emergence of a workforce with new competencies that are relevant to the green economy paradigm. In this context, the vocational education system and automotive engineering must adapt so that graduates are

not only mechanically proficient, but also understand and be able to apply environmental sustainability principles (Haloho, Pardjono, Saputro, Suyitno, & Ariwibowo, 2023). The integration of green skills into the vocational education curriculum is key to preparing competent graduates to face the challenges of the modern automotive industry (Adjei, Mulyanti, Abdullah, Ampimah, & OseiBonsu, 2024).

In the vocational education literature, the concept of Green TVET (Technical and Vocational Education and Training) emerged in response to the demands of environmental change and the green economy. Bibliometric studies show that the integration of Green TVET into vocational education has been carried out gradually through the renewal of curricula, pedagogy, and institutional practices (Adjei et al., 2024). This kind of integration is important so that vocational education, including automotive engineering, is able to produce graduates who are ready to face real green economy challenges. In Indonesia, the implementation of green skills in vocational education is starting to be seen.

Haloho, Pardjono, Saputro, Suyitno, and Ariwibowo (2023) found that students and teachers are aware of the importance of eco-friendly skills and behaviors, although there are still challenges in classroom implementation and laboratory practice. This research shows the need for a more structured learning strategy and media that supports the understanding of the concept of green skills effectively. In addition, the integration of industrial practice education models, such as Teaching Factory, with Green TVET has been identified as an effective approach to building student competencies. Putra, Janata, Dongoran, and Thomas (2025) show that this combination allows students to develop practical skills while also understanding the principles of sustainability. This implementation also supports the development of project-based curriculum and laboratory practices that are relevant to industry needs.

In the context of automotive engineering education, training on the conversion of vehicles from gasoline engines to electric motors becomes an effective learning medium. The study of Simarmata, Handayani, Pienrasmi, Ardiansyah, Hakim, and Hartabela (2025) revealed that the electric motorcycle

conversion program at SMK Kosgoro Penawartama succeeded in increasing students' knowledge, skills, and motivation, as well as producing vehicle units that were converted and road-tested. This program is a real example of the implementation of environmentally friendly technology-based automotive engineering education in Indonesia.

Thus, the integration of green technologies into automotive and vocational education is not only theoretically relevant through the framework of Green TVET and Teaching Factory, but has also shown real implementation in the field. Therefore, this literature review is important to explore the extent to which these concepts and practices have been implemented, what forms of media and learning methods are used, as well as future development challenges and opportunities, especially in the context of automotive engineering education in Indonesia (Maulana & Munawar, 2024; Mustapha, 2021).

METHODS

This study uses a literature review approach with the aim of analyzing the implementation of environmentally friendly technology in automotive engineering learning and identifying media, methods, and supporting factors for green skills development. This approach was chosen because it allows researchers to collect, compare, and synthesize findings from various academic sources and vocational education practices, so as to present a comprehensive picture of the concept and implementation of Green TVET in the automotive sector.

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RESULTS

1. Integration of Eco-Friendly Technology in the Curriculum

The results of the study show that several automotive engineering vocational schools in Indonesia have begun to integrate environmentally friendly principles into the curriculum, especially in basic automotive subjects and laboratory practices. The Green TVET-based curriculum includes the introduction of electric vehicles, energy management, and emission reduction practices. Haloho, Pardjono, Saputro, Suyitno, and Ariwibowo (2023) reported that students and teachers are aware of the importance of green skills in vocational education.

2. Learning Media and Methods

The use of digital media, electric vehicle conversion modules, and practical simulators has been proven to improve students' understanding of concepts. The study of Maulana and Munawar (2024) found that digital modules allow students to conduct virtual experiments before laboratory practice. The GO ELECTRIC program at SMK Kosgoro Penawartama (Simarmata et al., 2025) has succeeded in improving students' practical skills through the practice of converting gasoline motorcycles to electric motorcycles.

3. The Role of Teachers and Instructors

Teachers and instructors have an important role in the implementation of green skills. Teachers' competence in electric vehicle technology and digital literacy affects the effectiveness of learning (Haloho et al., 2023; Mustapha, 2021).

4. Challenge

Some of the challenges found include limited laboratory facilities, electric vehicle conversion devices, and differences in the digital literacy of teachers and students (Simarmata et al., 2025; Maulana & Munawar, 2024)

DISCUSSION

The results of the study indicate that the implementation of environmentally friendly technologies in automotive engineering education at Indonesian vocational high schools (SMKs) is beginning to receive serious attention. The integration of Green TVET principles into the curriculum provides a framework for students to study electric

vehicles, renewable energy, and emission reduction practices. Haloho, Pardjono, Saputro, Suyitno, and Ariwibowo (2023) emphasize that the development of green skills not only strengthens technical competencies but also cultivates students' environmental responsibility. This demonstrates that vocational education is no longer solely focused on mechanical skills but also on understanding sustainability principles, which are increasingly required by the modern automotive industry.

Learning media and methods play a significant role in the effective transfer of green skills. The use of digital modules and practical simulations, as developed by Maulana and Munawar (2024), enables students to gain in-depth theoretical understanding before applying it in the laboratory. This approach reduces practical errors, improves learning efficiency, and fosters problem-solving skills. Furthermore, the GO ELECTRIC program at SMK Kosgoro Penawartama (Simarmata et al., 2025) demonstrates that hands-on experience in converting gasoline motorcycles to electric motorcycles equips students with applicable technical skills while fostering environmental awareness through real-world practice. Through this project, students learn to integrate principles of electricity, mechanics, and energy efficiency holistically—an outcome difficult to achieve through theoretical learning alone.

The role of teachers and instructors is a key determinant of successful implementation. Teachers with technical competence and digital literacy can effectively facilitate the use of digital media, conversion modules, and practical simulations. Haloho et al. (2023) and Mustapha (2021) show that teachers' awareness of green skills enhances student motivation and learning quality. Conversely, limited teacher competence can reduce implementation effectiveness, especially when new technologies and practical methods are introduced.

Challenges remain significant, particularly regarding limited laboratory facilities and electric vehicle conversion equipment. Some SMKs still face constraints in providing adequate tools and trainers, as well as differences in teachers' and students' digital literacy levels (Simarmata et al., 2025; Maulana & Munawar, 2024). However, these challenges also present strategic

opportunities. The Teaching Factory model and electric vehicle conversion projects provide students with practical experiences close to real industry conditions, enhancing employability and instilling environmental awareness as part of professional competence (Putra, Janata, Dongoran, & Thomas, 2025). Thus, despite obstacles, integrating green skills through environmentally friendly technologies provides significant added value to automotive engineering education, preparing graduates who are competent, adaptive, and sustainability-oriented.

Overall, the findings confirm that implementing environmentally friendly technologies in automotive engineering education is not only theoretically relevant but also practically feasible with appropriate curricula, adequate learning media, and competent teachers. This integration is a critical strategy for SMKs to produce graduates ready to meet the demand

CONCLUSION

The results of the study indicate that the implementation of environmentally friendly technologies in automotive engineering education at Indonesian vocational high schools (SMKs) has begun to progress positively and aligns with the needs of the modern automotive industry. The integration of Green TVET principles into the curriculum, the use of digital modules, practical simulators, and electric vehicle conversion projects has proven effective in enhancing students' conceptual understanding, practical skills, and environmental awareness. The Teaching Factory model, when combined with Green TVET, provides learning experiences that closely simulate real industrial conditions, enabling students to apply theory directly to practice and develop green skills comprehensively.

The role of teachers and instructors is a key factor in successful implementation, as educators with technical competence and digital literacy can facilitate learning optimally and motivate students to understand sustainability principles. Despite challenges such as limited laboratory facilities, vehicle conversion equipment, and varying levels of

digital literacy, opportunities for implementing green skills remain significant. Hands-on practice and supportive learning media enable students to acquire applicable skills, foster environmental awareness, and prepare them to face the demands of the green automotive industry in the future.

Thus, this study confirms that the utilization of environmentally friendly technologies in automotive engineering education not only enhances students' technical competencies but also plays a critical role in cultivating sustainability awareness. As a result, vocational education can produce graduates who are adaptive, competent, and ready to meet the demands of a modern, green-skills-oriented industry.

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