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Enhancing the Business Model Engineering of Electric Motorcycle Conversion Workshops in Vocational High Schools

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Abstract

The Blue Sky Program is an Indonesian government initiative aimed at controlling air pollution. The government targets a reduction in carbon emissions of 0.038 to 0.056 gigatons through various policies, including the conversion of conventional motorcycles to electric vehicles as part of the national strategy. This electric vehicle conversion not only contributes to emission reductions but also creates business opportunities for conversion workshops and business entities. However, the adoption and diffusion of the electric motorcycle conversion business in Indonesia still faces several challenges, such as high conversion costs, inadequate supporting infrastructure, and a lack of skilled technical personnel. In addition, low consumer awareness and purchasing power hinder the widespread use of electric conversion vehicles. As a solution, collaboration with Vocational High Schools (SMK) engaged in automotive technology is being sought to strengthen the electric motorcycle conversion business ecosystem. The Problem-Based Learning (PBL) method is used as the primary strategy for developing solutions. This initiative is carried out through the Community Partnership Program (PKM), focusing on: (i) designing training modules on technology and business; (ii) conducting training on business engineering models for conversion workshops; (iii) providing business engineering assistance; and (iv) measuring the adoption and diffusion rate of conversion vehicle technology. Through this program, it is expected that partner conversion workshops can improve their business performance, ultimately contributing to the acceleration of electric vehicle adoption and diffusion in Indonesia.

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INTRODUCTION

The rapid growth in the number of motorcycles in Indonesia has had a significant impact on increasing carbon emissions. By 2024, the number of motorcycles in Indonesia had exceeded 125 million units (Oktaviastuti & Wijaya, 2017), contributing to air pollution and increased greenhouse gas emissions (Nugroho et al., 2024). In line with global efforts to reduce emissions from the transportation sector, the Indonesian government has launched the Blue Sky Program as a national strategy to control air pollution, particularly from vehicles powered by fossil fuels. This program is supported by various regulations, including Presidential Regulation Number 61 of 2011 concerning the National Action Plan for Reducing Greenhouse Gas Emissions, which targets a reduction in carbon emissions of 0.038 to 0.056 gigatons from the transportation sector.

One of the policies developed in the Blue Sky Program is a program to convert fossil fuel-powered motorbikes into battery-based electric motorbikes (Widiawati et al., 2024; Zainida et al., 2022). This program aims to reduce vehicle pollution while reducing dependence on imported fuel oil (BBM). To support the adoption and diffusion of electric conversion vehicles, the government has issued various regulations, such as Permenhub PM 39/2023 concerning the conversion of fuel-powered motorbikes to electric and Regulation of the Minister of Energy and Mineral Resources Number 3 of 2023 concerning guidelines for government assistance in the conversion program (Fahmi, 2023; Subiantoro & Maharani, 2024).

Although the conversion program has been running for the past 2–3 years, its implementation still faces various challenges, including high technology costs, limited supporting facilities, and a lack of skilled technicians (Ananda, 2021; Aqidawati, 2022; Rahmawati et al., 2022; Yuniaristanto, Afraah, et al., 2023). On the other hand, this program opens up business opportunities for conversion workshops and business entities involved in the electric vehicle ecosystem. Therefore, efforts are needed to strengthen the conversion workshop business engineering model, one of which is through partnerships with Vocational High Schools (SMK) that have automotive technology majors. This collaboration is expected to accelerate the adoption and diffusion of electric conversion vehicles, as well as improve the quality of the workforce in the electric vehicle industry sector. The low willingness to adopt from the community can have an impact on the loss of opportunities to drive the economy from renewable energy (Aqidawati et al., 2022; Arifin, 2017; Sulistyono et al., 2021; Utami et al., 2020; Yuniaristanto, Sutopo, et al., 2023b).

One of the strategic steps in accelerating the adoption of converted electric vehicles is to increase the level of technology acceptance in society. (Agustina et al., 2025; Kirana et al., 2023; Murtiningrum et al., 2022; Yuniaristanto, Sutopo, et al., 2023a). In this effort, the UNS Research Group Grant Community Service Program (PKM HGR), initiated by the Industrial Engineering and Techno-economics Research Group (RITE), Industrial Engineering Study Program, Faculty of Engineering UNS, plays a role in integrating two main programs, namely "Technology Diffusion Learning Media" and "Evaluation of Technology Acceptance Level". The implementation of this program is carried out collaboratively with the Electric Vehicle and Sustainable Energy Research Group, Faculty of Engineering, UNS, and the Artificial Intelligence Research Group, Electrical Engineering Study Program, Faculty of Engineering, UNS, which have a track record in research and development of technological innovations to support carbon emission reduction.

In the context of strengthening the business engineering model of conversion workshops in vocational schools, this technology-based approach is crucial to overcome challenges in the adoption and diffusion of converted electric vehicles. The integration of technology diffusion learning media enables more effective knowledge transfer between academics, conversion workshops, and vocational schools, allowing students and business actors better to understand the benefits and technical procedures of conversion. In addition, evaluating the level of technology acceptance helps identify barriers to adoption in the community and develop appropriate strategies to increase the competitiveness of conversion businesses. With this systematic and research-based approach, it is hoped that the business model of conversion workshops in vocational schools can be more sustainable, competitive, and contribute to achieving the Sustainable Development Goals (SDGs), especially in terms of reducing CO_2 emissions and developing environmentally friendly technologies (Aqidawati et al., 2020).

In order to implement the conversion workshop business engineering model in Indonesia, the Industrial Engineering Study Program and Techno-economic Research Group (GR) of the Industrial Engineering Study Program, Faculty of Engineering, UNS, together with the GR of Electric Vehicles and Sustainable Energy, FT UNS and the GR of Artificial Intelligence, Electrical Engineering Study Program, FT UNS, propose a series of activities that focus on technology diffusion and increasing the acceptance of electric vehicle conversion technology. The main activities proposed include: (i) Preparation and implementation of "Technology Diffusion Learning Media" as a means of education for students and teachers in vocational schools regarding the principles, benefits, and technical processes of electric motorcycle conversion; (ii) Training and mentoring of the business engineering model of conversion workshops, which includes marketing strategies, cost analysis, and operational management to ensure the sustainability of conversion workshop businesses in vocational schools; and (iii) Evaluation of the Level of Technology Acceptance, which aims to identify factors that influence the adoption of conversion technology by students, teachers, and the wider community.

This program aims to improve the understanding of conversion technology among 40 partner vocational high school participants through technology-based learning media, holding two conversion workshop business training sessions, and collecting technology acceptance data from 40 respondents for analysis and formulation of adoption strategies. Thus, it is hoped that vocational high schools can play a strategic role in creating a skilled workforce in the electric vehicle sector, while building a stronger and more sustainable conversion business ecosystem. Furthermore, through technology acceptance evaluation, the insights gained can be used to design more effective policies to encourage the adoption and diffusion of electric vehicle conversion in the community.

MATERIALS AND METHODS

This activity applies the Problem-Based Learning (PBL) method as the primary approach to identifying solutions to problems encountered in vocational

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education settings. The process involves identifying problems in vocational high schools, collaborating with stakeholders to generate potential solutions, determining learning needs for improvement, conducting research to support solution development, and presenting, implementing, and evaluating the developed solutions.

The problem focuses on the lack of human resource capabilities in vocational schools in developing electric motorcycle conversion workshop business units independently, both from technical and managerial aspects. Through the PBL approach, the community service team, consisting of lecturers, students, and industry players, not only provides one-way training but also, together with teachers and vocational school students, identifies the main problems, formulates needs, and designs applicable solutions. Students can participate in field studies, develop business models for conversion workshops, and develop technical standard operating procedures (SOPs) for standardized vehicle conversions. This learning encourages cross-disciplinary collaboration and enhances students' critical thinking skills, while empowering vocational schools to develop sustainable workshops ready to meet the challenges of the electric vehicle industry. PBL effectively improves the quality of experiential learning and provides a tangible impact on society.

This activity is carried out in several stages, namely (1) designing learning media and training modules, (2) implementing training and workshops, (3) mentoring and implementing business engineering, and (4) evaluating the level of technology acceptance. In the first stage, the Research Group (GR) of Industrial Engineering and Techno-economics (RITE) of the Faculty of Engineering, UNS, in collaboration with GR Electric Vehicles and Sustainable Energy and GR Artificial Intelligence, will design a technology-based learning module that covers technical aspects of electric motorcycle conversion, business strategies, and related regulations. This module will serve as the primary guide for the training process at SMK.

The second phase includes training aimed at vocational high school students and teachers. Training sessions will cover the technical aspects of battery-based motorcycle conversion, business strategies for conversion workshops, and the use of digital technology in workshop marketing and management. This activity involves industry practitioners, academics, and certified conversion workshops, so participants can gain hands-on experience in conversion practices and workshop management. The third phase includes intensive mentoring for vocational high schools and conversion workshops to implement the designed business models. This mentoring includes business simulations, business feasibility analysis, marketing strategy development, and partnerships with industry.

The final stage is the evaluation of the level of technology acceptance, which aims to measure the extent to which students and teachers understand, are interested in, and are ready to adopt and implement electric vehicle conversion technology.. This evaluation will be conducted through surveys, interviews, and case studies, with the results serving as a basis for improving the program and providing recommendations for stakeholders in developing the electric vehicle conversion ecosystem in Indonesia (Fig. 1).

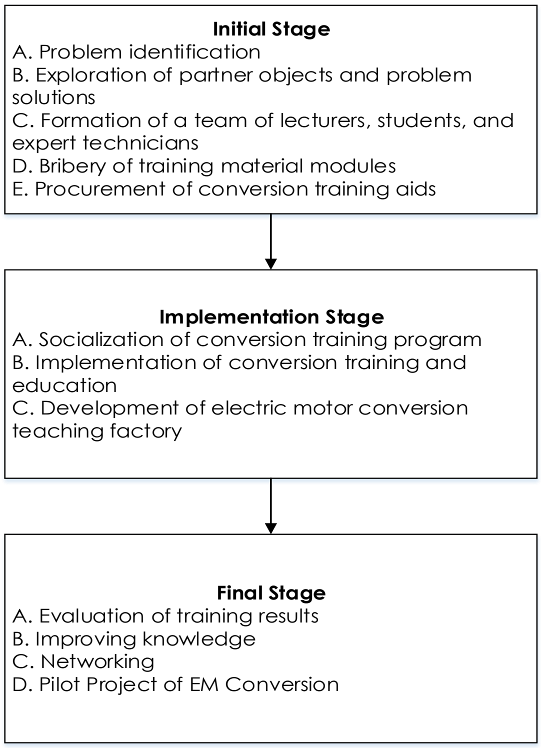

Fig. 1. Flowchart for implementing community service regarding electric motorbike conversion

RESULTS AND DISCUSSION

Initial Stage

The first step taken was to determine the main problem to be addressed, namely that the current level of adoption of electric vehicle conversion technology diffusion remains low, human resources with the ability to convert vehicles are still limited, and there is no suitable business model. The pre-test results indicate that both teachers and students have limited familiarity with motorcycle conversion technology. Then, the research group-initiated community service at vocational high schools, providing human resources with skills in light vehicles. Then, it continued with the formation of an observation team to evaluate the learning materials

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used in vocational high schools. Additionally, the research group collected data on the potential and obstacles currently faced by vocational high schools through interviews and observations.

Implementation Stage

This stage begins with compiling activity steps based on solving real problems experienced by community service partners, namely, vocational high schools. The research group also conducts socialization sessions with partners by presenting experts and researchers who are leaders in the field of electric vehicles and their ecosystems. From this socialization, it is also known that the low level of adoption of electric vehicles in Indonesia, especially in Central Java Province, is another contributing factor.

Fig. 2. Community service socialization by the research group to the vocational high school

Fig. 3. Handover of converted motorcycles to vocational high school

The next stage involves implementing electric vehicle conversion training for vocational high school students and teachers. This training aims to provide experience and knowledge for vocational high school students and teachers regarding the conversion procedure from start to finish. At this stage, the industry is involved as a business actor, providing training to vocational high school students and teachers. This training resulted in the successful conversion of two ICE (Internal Combustion Engine) motorcycles. During the training process, vocational high school students and teachers were accompanied and guided by business actors.

The implementation of PKM began in March 2024 by conducting survey preparation, determining the schedule, and compiling the training agenda. Socialization with teachers and students of vocational high schools was conducted in July 2024, and the handover of the converted motorbikes took place in December 2024. Documentation of the implementation and outputs is presented in Fig. 2 and Fig. 3.

Final Stage

At this stage, the monitoring and evaluation of the activities carried out are conducted. The research group received feedback from vocational high schools as participants in vehicle conversion training. It is valuable input for the industry to improve and become better. Table 1 shows changes obtained by partners based on the results of the activities.

Table 1. The changes obtained by partners based on the results of the activities

Initial Condition	Intervention	Condition Change
Teachers and students are not yet familiar with motorcycle conversion technology.	Training and workshop on introducing electric motorcycle conversion systems and processes	Teachers and students are able to understand the basics of vehicle conversion technology and can make simple prototypes.
There is no simple workshop manageme nt system in the school business unit	Introduction to workshop manageme nt system	Teachers and students can start managing work processes, ordering, and reporting in a structured manner.

Evaluation activities are conducted in collaboration with community service partners and community service teams. Providing a question-and-answer session for 40 participants can help community service partners offer feedback on the implemented programs and serve as an evaluation for the community service team to improve their activities further. Additionally, the monitoring process is conducted twice and is performed directly on site. The first monitoring was carried out 14 days after the community service activity. Within the first 14 days

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following the community service activity, the monitoring results indicated positive developments in the understanding of community service partners who participated in the electric vehicle conversion training.

The results of this community service program indicate that implementing the conversion workshop business engineering model in vocational high schools can enhance technical understanding, business skills, and the readiness of educational institutions to support the electric vehicle conversion ecosystem. Post-training and workshop evaluations suggested that 70% of participants, including students and vocational high school teachers, had a better understanding of the ideas and processes involved in electric motorbike conversion. The business model mentoring activity also had a beneficial influence on mimicking the conversion workshop business in the vocational high school setting, as participants were able to create a simple business plan, a conversion cost analysis, and digital marketing strategies.

Furthermore, the study of technological acceptability found that students' interest in electric vehicle conversion technology increased by 60%, especially after being presented to the industry's market potential and business opportunities. However, significant problems remain in executing this program, including a lack of tools and supporting infrastructure in vocational high schools, as well as limited student access to direct practice in the conversion business. As a result, greater collaboration is required among vocational high schools, certified conversion workshops, and related sectors to assure the program's sustainability and assist the improvement of vocational high school graduates' competence in the field of electric vehicles.

Overall, this program has successfully demonstrated that with a training-based approach, mentoring, and technology acceptance evaluation, vocational high schools can become part of a sustainable conversion workshop ecosystem, while contributing to accelerating the adoption of electric vehicles in Indonesia and meeting carbon emission reduction targets in accordance with the Blue-Sky Program and Sustainable Development Goals (SDGs).

This program's conversion motorcycles use technical specifications that are adapted to regulatory standards and user requirements. The conversion procedure is replacing the internal combustion engine (ICE) with a battery-powered electric motor, which attempts to reduce carbon emissions and improve energy efficiency. The major features of this conversion motorbike are an electric motor with a power range of 2 kW, capable of delivering a maximum speed of roughly 70-90 km/h, depending on the battery capacity and vehicle weight.

The electric motor's primary power source is a 48V to 72V lithium-ion battery with an energy storage capacity ranging from 20Ah to 50Ah, allowing for a range of approximately 50-100 km per charge. The battery charging mechanism enables both fast and slow charging, with charging periods varying from 2 to 6 hours, depending on the charger used. This conversion motorbike is fitted with an electronic controller unit (ECU) that governs the power distribution from the battery to the electric motor and a regenerative system to boost energy efficiency during braking.

In terms of safety, the modified motorcycles met electric vehicle safety standards, which included a waterproof electrical system (IP67), an automatic power cut-off system in the event of a disturbance, and a thermal protection mechanism on the battery to prevent overheating. The vehicle frame design preserves its original structure, with modifications to allow for the installation of electrical components. Table 2 displays the parameters of the adapted motorcycle.

Table 2. Conversion motorcycle specifications

No.	Description	Specification
1	BLDC Dynamo	BRT Dynamo BLDC 72V 2KW
2	Controller	Juken 10 EV BRT
3	Battery	BRT Battery Lithium Ion 72V/20Ah
4	Ignition Key and Starter	Greenlight
5	Battery socket and cable	Chogori IP67
6	Port Charger	IP67
7	Bracket for battery and controller	SS400; 2mm; painting
8	Bracket for BLDC motor	SS400; 2mm; painting
9	Battery charger	600W
10	MCB	65A
11	DC-DC Converter 72V to 12V	Input voltage: 36-72V; Output voltage; 12V; Output current; 20A
12	Dioda protection	20A; 1000V
13	Throttle position sensor	Cable 3pin + 5V, GND, Hall sensor
14	Body cable	AWG18; AWG10

With these specifications and an investment of around IDR 28,000,000, including installation and testing costs, the converted motorcycle is not only environmentally friendly, but it also has competitive performance and lower operating costs than fossil fuel vehicles, making it a more sustainable transportation solution for the future. As part of the community service program, we converted two motorcycles. Gasoline-powered (ICE) motorcycles emit pollutants such as CO_2, NO_x, and particulates during operation, with CO_2 emissions reaching up to 179.17 grams per kilometer. In contrast, electric motorcycles—especially those powered by renewable energy—can reduce CO_2 emissions by up to 75% compared to their gasoline counterparts. Publication of activities in online mass media with various scientific and popular scientific articles presented in the form of published opinions in the Solo Pos media, both print and online editions (Fig. 4).

Fig. 4. Online publication as a form of dissemination to the public (Bantara, 2024)

CONCLUSION

This community service program aimed to strengthen the business model of electric motorcycle conversion workshops in vocational high schools. Through the development of instructional media, technical and business training, business model mentoring, and evaluations of technology acceptance, the program enhanced the knowledge, skills, and motivation of both students and teachers in testing converted vehicles. The participants gained practical experience in electric motor systems, component installation, and vehicle testing. Key accomplishments were the active participation of 40 participants, the effective conversion of two motorcycles for school use, and the creation of training modules that may be integrated into vocational school curriculum. The program significantly increased 40 vocational students' grasp of electric motorbike conversion, as evidenced by a 35% rise in pre- and post-test scores. Two business training sessions were held, and 40 respondents' technology acceptability ratings were recorded. Overall, the project met its objectives and helped to promote the adoption of EV conversions in partner schools.

In addition to assisting vocational schools in developing technical and entrepreneurial competencies, the initiative contributed to research by giving useful data on the spread of EV conversion technology. However, the program encountered various obstacles, including a short implementation time and different degrees of students' underlying understanding in electrical principles, which hampered learning progress. To solve these challenges, future initiatives may include continued mentoring, the construction of a tiny conversion lab in schools, and advanced training in areas such as controller programming, battery management, and electric vehicle performance monitoring.

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