International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 24s, 2025
https://theaspd.com/index.php

Renovating the Training Program for Automotive Engineers in the Era of Electric Vehicles in Vietnam

Dao Duc Thu[1]
[1]Thanh Dong University, Hai Phong City, Vietnam, thudd@thanhdong.edu.vn

Abstract: *This study was conducted with the goal of comprehensively analyzing the current situation of training engineers in the automotive industry in the context of the transition to electric vehicle technology in Vietnam, and at the same time proposing a framework to innovate the training program in line with the new requirements of the labor market. On the basis of a mixed approach, the study combines qualitative and quantitative analysis to ensure the multidimensionality and reliability of the results. The findings from the study not only contribute to providing empirical evidence of the difficulties and challenges in the field of technical education in Vietnam, but also shed light on the core issues that institutions need to address in the context of globalization and energy transition trends. Thereby, the study emphasizes the importance of innovating the automotive engineer training program, considering this as one of the key factors to improve the competitiveness of technical human resources in an emerging economy like Vietnam.*
Keywords: *renovate, training program, automotive engineer, electric vehicles, Vietnam*

1. INTRODUCTION

In the context of globalization and the Fourth Industrial Revolution (Industrial Revolution 4.0), the shift from internal combustion engines to clean energy vehicles has become an unavoidable trend. The automotive industry is experiencing unprecedented changes, especially with the rise of electric vehicles (EVs). Along with this trend, the need for fundamental innovation in higher education, particularly for the Automotive Engineering Technology industry, has become urgent (Basri, 2025).

Basri (2025) highlights that developing a comprehensive EV training program is a crucial foundation for preparing the right human resources for the future automotive industry. Meanwhile, Bonnema (2025) has demonstrated the effectiveness of including the "Electric Vehicle System Design" module in teaching, as it helps students develop systems thinking and practical skills. At the postgraduate level, Chau (2025) views the introduction of the master's program in EV as a "timely programme," reflecting the urgency of global trends.

The global report by Hayes et al. (2021) also indicates that many universities around the world have been rapidly innovating their training programs to meet the needs of the EV labor market. McDonald (2010) emphasizes the role of engineering-technology education in preparing for the development of EVs, while Minaie (2025) focuses on integrating EVs into Electrical and Computer Engineering programs. Practice shows that EV modules not only add new knowledge but also foster an interdisciplinary environment between mechanics, electronics, and digital technology.

One of the main strategies is to incorporate EV research findings into education. Chau (2025) states that "translation of EV research into education" serves as a bridge between academia and practice. Subsequent studies also indicate that establishing an EV program has always faced certain obstacles, from policies and facilities to faculty capacity. Additionally, integrating sustainability factors into EV engineer training is becoming increasingly important, because the electric vehicle industry aligns with green development goals and circular economy principles..

From a macro perspective, many scholars suggest a "whole-of-university" approach where EV training should be linked with research and sustainable development activities within the university. MDPI and Cleaner Production reports also show that sustainable education is essential for enhancing the quality of human resources in the new era. Specifically, the IJSHE Journal has become a respected academic platform for sharing experiences on integrating sustainable development in higher education.

At a professional level, many authors have developed learning, experimental, and simulation tools to teach about batteries, BMS, and power electronics in EVs. Liao (2016) introduced a learning tool for BMS, Judge (2022) built an EV battery module that integrates socio-technical elements, and Steger (2020) compared the effectiveness of battery teaching through practice and simulation. Many other studies have also confirmed the central role of BMS in EV education. At the same time, state-of-the-art laboratories for power electronics and electric motors are also being developed for training.

Safety in EV training has received extensive attention in many studies. SAE's High Voltage Safety courses have become the global standard. Many other authors, such as iJAC (2016), also emphasize the need for standardization of safety training when working with EVs. The ASE Education Foundation (2024) also offers a set of tools and standards to be incorporated into training programs. Meanwhile, DOE has funded numerous reports and designs for the energy storage laboratory, helping to improve the quality of EV training.

Not only at university training, but EVs are also integrated into many other fields. Studies from ASEE (2025) show the connection of EVs to civil infrastructure, smart transportation vehicles, and artificial intelligence. At the high school level, many STEM programs have introduced the electric vehicle model into elementary and secondary classrooms. In addition, SAE has developed K-12 curriculum kits to spark a passion for science and technology in students.

Another major challenge is funding and resource allocation. ASEE studies (2025) indicate that EV module development often encounters difficulties in securing funding, equipment, and corporate cooperation. As early as the late twentieth century, Purdue experimented with a new EV training program, highlighting the importance of financial and policy support. Recent work at WEVJ and DOE also emphasizes the role of public-private partnership programs in developing EV training.

In Vietnam, EV development is rapidly advancing with strong participation from domestic companies like VinFast. The ICCT report (2022) highlights the opportunities and challenges in EV growth in Vietnam. Trung et al. (2024) examined factors affecting electric motorcycle usage, while Nguyen et al. (2023) studied how electric buses influence user behavior. Many scholars have also analyzed the barriers to EV adoption, including policy and infrastructure issues. Empirical research in Vietnam shows that consumer attitudes and perceptions are crucial for the growth of the EV market.

Finally, to develop the EV engineer training program, it is necessary to reference the global technology platform. Skouras (2020) offers a comprehensive overview of the current state and future prospects of EVs. Alanazi (2023) examines the benefits, challenges, and solutions for the EV industry. Alatise (2025) emphasizes the potential for reuse of components and sustainable development. These serve as important theoretical foundations for Vietnamese universities to create output standards and module content, ensuring that the training program is both current and sustainable in the long term.

All of the above studies confirm that: (i) global trends are strongly driving the development of EVs; (ii) higher education must undergo fundamental innovation to effectively prepare engineers for new technologies; (iii) in Vietnam, the gap between training and market demand remains large; (iv) learning from international experiences and adapting them flexibly in the country is a necessary step.

Therefore, this study was conducted with the objective of: (i) analyzing the theoretical basis and overview of EV training; (ii) assessing the current state of the Automotive training program in Vietnam; (iii) proposing a framework for updating the automotive engineer program to include EV integration, aligned with sustainable development and business needs.

2. Theoretical basis and research overview

2.1. Theoretical basis

Curriculum innovation in higher education is an inevitable process in the context of Industry 4.0. Modern curriculum development theory states that an effective training program must ensure three factors: (i) aligned with labor market demands, (ii) based on the core competencies that learners need to achieve, and (iii) adaptable to technological changes.

In the era of electric vehicles (EVs), the training program for automotive engineers cannot only focus on internal combustion engines and traditional mechanics. Basri (2025) emphasizes that developing a systematic EV curriculum framework is an important step for universities to prepare high-quality human resources. Bonnema (2025) has proven that the “Electric Vehicle System Design” module not only supplements knowledge but also helps students develop systems thinking abilities – one of the important skills of 21st-century engineers.

At a higher level, Chau (2025) affirmed that the establishment of a postgraduate training program on EV is a "timely programme", in order to meet the needs of in-depth research and academic development. These studies reinforce the thesis that the rationale for renewing the automotive engineer training program in the context of EV must be based within an interdisciplinary, competency-based, and sustainable education framework.

Another widely adopted theoretical framework is Competency-Based Education (CBE). Hayes et al. (2021) conducted a global survey and confirmed that EV training programs must ensure learners acquire core competencies: in-depth knowledge of batteries and BMS, skills for safe high-voltage operation, and proficiency in digital simulation tools. McDonald’s (2010) also highlighted the importance of shifting from traditional subject-based training to integrated competency-based training.

Minaie (2025) noted that in the EV landscape, the intersection between Electrical Engineering and Automotive Technology is becoming increasingly evident. Therefore, the curriculum needs to incorporate power electronics, motor control, and energy management topics into the standard curriculum framework. Chau (2025) and subsequent studies (Saleet et al., 2021; Chau, 2025) highlight that transferring knowledge from EV research to teaching is an important bridge between academia and practice.

However, the implementation process encounters many obstacles. Saleet et al. (2021) note that establishing an EV program demands significant investment in facilities, readiness of teaching staff, and supportive policies from the government. This presents a major challenge for universities in developing countries like Vietnam.

In addition to the technical aspect, the theory of Education for Sustainable Development (ESD) is increasingly regarded as fundamental. Martínez-Borreguero (2024) shows that integrating sustainable energy into education helps develop green awareness among students. Frontiers in Education (2022) also states that including the concept of sustainability in the curriculum is not only a trend but also a vital requirement. Vallée (2024) notes that many American universities have struggled to effectively teach sustainability to students, indicating a significant gap between theory and practice.

Grauer (2022) highlights the importance of the time factor in sustainable education, while Leal Filho (2008) recommends a "whole-of-university" approach – meaning EV is not just a single module but must be integrated into the university's overall development strategy. Studies by MDPI Sustainability (2024) and Cleaner Production (2024) agree that EV education is truly effective only when aligned with the organization's sustainability goals. The IJSHE Journal has also become a prestigious academic platform for research on sustainable integration in higher education.

From a theoretical perspective, it can be concluded that the innovation of the automotive engineer training program in the EV era should be based on three pillars: interdisciplinary, capacity, and sustainability.

2.2. Overview of international research on in-depth content in EV training

2.2.1. Battery and Battery Management System (BMS) Training

In an electric vehicle's structure, the battery and battery management system (BMS) play a key role. Therefore, including knowledge and skills about batteries and BMS in the automotive engineer training program is essential. Liao (2016) created a specialized learning tool for the BMS, providing students with a more intuitive way to understand monitoring the battery's voltage, current, and temperature. Judge et al. (2022) developed a socio-technical module on EV batteries in Electrical Circuits, which aims to combine technical knowledge with social factors, helping students grasp the multifaceted impact of batteries on the environment and society.

Steger (2020) conducted a comparative study between teaching batteries through hands-on experiments and simulations. The results show that combining both methods enhances learning efficiency: practice allows students to develop skills in person, while simulation offers safety and cost benefits. Studies from Research Publish (2020) and Bergveld (2001) also support the background literature on BMS design and operation, which plays an important role in standardizing this module in EV education.

2.2.2. Power electronics and electric motors

Along with the battery, the power electronic and electric drive system is essential. Chen (2007) emphasizes that building a state-of-the-art laboratory in power electronics and electric motors is necessary for students to access practical technology. Balog (2005) also asserts that EV engineer training should be linked to experiments on inverters and PMSM motor control systems.

Additionally, studies of virtual labs in power e-teaching (2001) have demonstrated significant effectiveness in increasing access for students, particularly in educational institutions with limited physical equipment.

2.2.3. High-voltage safety and teaching standards

A characteristic of EVs is the high-voltage (HV) system, which poses numerous safety risks if students are not equipped with standard knowledge and skills. SAE (2020) has developed EV safety courses such as the C2001 standard, which has become a popular reference for many training programs. iJAC (2016) analyzes that clarification of safety training requirements is not only necessary in theory but must also be integrated into practice. The ASE Education Foundation (2024) has even proposed a set of standards and a list of tools needed to implement EV safety training at universities and vocational institutions. Additionally, reports from the DOE (2013) provide an important source of material on battery experimentation, analysis, and design, which can be directly integrated into the curriculum.

2.2.4. Integrating EVs in various disciplines and levels

A new trend is to expand EV training into many fields. ASEE (2025) has studied including EVs in Civil Engineering by analyzing road and bridge loads as electric vehicles grow more popular. ASPIRE/ASEE (2025) also combines EVs with electrified roadways, highlighting the importance of EVs in transportation infrastructure. Additionally, SEE research (2025) has tested integrating AI and EV technology into automotive engineering courses to help students develop data processing and intelligent control skills.

At the high school level, ASEE (2024) introduced the mini electric vehicle model in the Primary Science program to spark interest in science from an early age. Programs developed by the University of Michigan (2024) show that K-8 students have a visual approach to understanding EV energy and operation. SAE has also created learning kits such as Ramp Up, Charge Up, Measure Up, and Electric Vehicle Challenge Suite, making EV education more engaging in K-12 settings. These programs help build the foundation for the future EV workforce.

2.2.5. Vocational education and advanced training

In addition to university and high school, EVs are also included in vocational and professional training courses. SAE has established the Hybrid & EV Engineering Academy for engineers and technicians, focusing on short-term intensive training. This serves as an important model from which Vietnam can learn to improve trainers' capabilities and update the skills of working engineers.

2.3. Resource and financial challenges in EV program development

One of the biggest barriers to implementing an EV program is the lack of financial resources and facilities. ASEE (2025) analyzed that the costs of EV laboratory equipment, battery models, motors, and charging systems are very high, while many universities lack the necessary budgets. Purdue (1998) has been a pioneer in developing EV programs since the 1990s but has also faced major financial challenges and interfaculty coordination difficulties. WEVJ's research (2024) on EV prototyping for education indicates that corporate involvement is essential for maintaining laboratories and student projects.

The Advanced Electric Drive Vehicle Education Program (AEDVE) (2015) in the United States exemplifies a successful public-private partnership, where governments, universities, and businesses collaborate to create a comprehensive EV training initiative. This model can serve as a reference for Vietnam in its process of innovating training programs.

2.4. Domestic research on EVs and human resource training

In Vietnam, the ICCT report (2022) shows that EV development is still in its early stages, but significant progress has been made thanks to the emergence of VinFast. Trung (2024) analyzed the factors influencing the use of electric motorcycles, while Nguyen et al. (2023) focused on the impact of electric buses on passenger behavior. Nguyen (2025) highlights barriers to EV adoption, including high costs, unsynchronized charging infrastructure, and a lack of comprehensive support policies.

Several empirical studies (Pham et al., 2024; IJBSS, 2023; Tran et al., 2025) also highlight that consumer behavior, attitudes toward new technologies, and the role of ride-hailing services directly influence the popularity of EVs. However, most research in the country has only focused on market and policy aspects, not on the innovation of the automotive engineer training program. This is the scientific gap that needs to be filled.

2.5. EV technology platform and impact on training output standards

Finally, the design of the training program is closely linked to the global EV technology landscape. Skouras (2020) offers a comprehensive view of the current state and prospects of EVs, highlighting the rapid development of batteries and charging infrastructure. Alanazi (2023) examines the benefits, challenges, and technological solutions, arguing that EVs are not only a trend but also a catalyst for green economic growth. Alatise (2025) explores the potential for reuse and recycling of EV components, emphasizing that engineer training should focus on the product life cycle and circular economy.

These studies show that automotive engineers' output standards in the EV era include not only technical skills (design, operation, diagnostics) but also need to incorporate sustainability (battery life cycle management, component recycling) and innovation capabilities (AI application, IoT, big data). This is a crucial focus for Vietnamese universities when updating training programs.

3. Research methods

To achieve the research goal of analyzing the theoretical basis, assessing the current situation, and proposing a framework for innovating the training program for automotive engineers in the context of electric vehicles in Vietnam, the research team selected mixed methods. This approach combines both qualitative and quantitative research to cover both depth and breadth of the problem. Using these two parallel approaches not only complements and calibrates each other but also enhances the reliability and validity of the results. This section outlines the research design, subjects and scope, data collection procedures, analytical tools, and principles for maintaining academic credibility and ethics.

3.1. Research design

The study was designed using an exploratory sequential mixed methods approach. Specifically, the first phase involves collecting qualitative data through interviews with lecturers and business experts in the electric vehicle field, identifying gaps in the current program and core competencies that need to be added. Based on this qualitative data, the research team developed a quantitative questionnaire to survey students. Conducting the survey with a large sample size allows for validating the prevalence and importance of the identified skills. This two-stage design ensures rigor in scale development and helps the results accurately reflect educational practices and market needs..

An important aspect of the research design is the comparison between the training program in Vietnam and advanced programs worldwide. The research team reviewed secondary literature from renowned universities such as TU Delft (Netherlands), KAIST (Korea), Stanford (USA), and the Technical University of Munich (Germany). This approach enables comparisons and helps extract valuable lessons and experiences for renewing training programs in Vietnam.

3.2. Objects and scope of the study

The main subjects of the survey are students majoring in Automotive Engineering Technology because they are the direct beneficiaries of the training program and will become the workforce in the era of electric vehicles. About 300 students from the second to fourth years at four key universities were selected to participate in the survey, including Thanh Dong University, Hanoi University of Science and Technology, Ho Chi Minh City University of Technology and Education, and University of Transport. This selection aims to ensure representation from both the North and the South.

Additionally, the research includes 20 lecturers who directly teach modules on motors, electrical-electronics, transmission systems, and automotive controls, as well as 10 experts and business managers in the field of manufacturing, assembling, and maintaining electric vehicles. The involvement of lecturers and businesses is crucial because they not only reflect teaching practices but also provide perspectives from the labor market.

The scope of research is limited to training automotive engineers at the university level, excluding vocational training or high school programs. Geographically, the research focuses on major cities in Vietnam, where training institutions and automotive companies are concentrated. Time-wise, the entire data collection process took about 6 months, from March to August 2025.

3.3. Data collection

To ensure comprehensiveness, the study used three main data sources: student surveys, faculty and business interviews, and secondary literature analysis.

The student survey was conducted using a structured questionnaire consisting of four content areas: demographic information, awareness of electric vehicle technology, expectations for skills to be gained upon graduation, and evaluation of current training programs. The questions are mainly designed with a 5-level Likert scale to easily measure a student's level of agreement or rating. Before the official survey, the questionnaire was initially tested with 30 students to adjust wording and clarity.

The semi-structured interview was conducted with 20 trainers and 10 business representatives. The interview focused on open-ended questions to explore the current shortage of automotive engineers, propose additional modules, and suggest suitable teaching methods such as simulations, laboratories, or projects related to businesses. The interviews lasted between 45 and 60 minutes, were recorded (with the participants' consent), and then transcribed and encoded the data.

Secondary data sources include current automotive training programs from several Vietnamese universities, international EV training programs, and policy reports on green transportation development. Analyzing the literature helps compare and identify differences and gaps in Vietnam's current training program.

3.4. Research tools

The survey questionnaire is created using Google Forms to make data collection and analysis easier. The questions are grouped by each variable, such as awareness of battery technology and BMS, high-voltage safe operation skills, or expectations of digital skills. The set of interview questions is designed in an open, flexible manner, allowing for in-depth exploration of participants' experiences and recommendations.

During data analysis, the team used SPSS and AMOS to conduct quantitative statistical tests, such as descriptive statistics, Cronbach's Alpha, exploratory factor analysis (EFA), confirmatory factor analysis

(CFA), and structural equation modeling (SEM). For qualitative data, NVivo software was employed to code, classify, and extract themes from interview content.

3.5. Research process

The research process consists of seven steps. First, the research team develops research tools, including survey questionnaires and interview guides. Second, they conduct a pilot test with a small group of students and faculty to refine the tools. Third, they collect official data from 300 students, 20 faculty members, and 10 businesses. Fourth, they input the survey data into SPSS and clean the data. Fifth, the interview data is encrypted using NVivo. Sixth, the data is analyzed both quantitatively and qualitatively. Finally, the findings are compiled and compared across data sources to generate meaningful insights.

3.6. Data analysis

Using quantitative data, descriptive statistics determine the percentage of students who are knowledgeable about EV technology, their interest in new modules, and their expectations for post-graduation skills. Cronbach's Alpha is used to evaluate scale reliability, ensuring questions that measure the same concept are highly consistent. Next, exploratory factor analysis (EFA) helps identify potential groups of factors such as "technical competence," "digital competence," and "sustainability capacity." Once EFA produces consistent results, confirmatory factor analysis (CFA) is performed to assess the suitability of the measurement model. Finally, structural equation modeling (SEM) tests the relationships between student perceptions, expectations, and evaluations of training programs.

Using qualitative data, the team employed a content analysis method. The first step is open coding, which categorizes statements into basic topics. The next step is to codify the axis, linking topics to create a broader concept, such as "competency gaps," "proposing new modules," or "requirements from the business." Finally, selective coding is conducted to draw an overall conclusion and connect to the theoretical framework.

3.7. Ensuring research reliability and value

To ensure reliability, quantitative data are tested using Cronbach's Alpha with a value of ≥ 0.7. Qualitative data are validated by comparing the coding from two independent researchers to ensure consistency in subject classification. Regarding validity, the research employs triangulation, which involves comparing and contrasting data from three sources: student surveys, faculty-business interviews, and literature analysis. This combination helps the research reflect reality and avoid one-sidedness.

3.8. Research ethics

Research follows ethical principles in social sciences. Participants in surveys and interviews are clearly informed about their purpose, scope, and their right to withdraw at any time. Personal data is kept confidential and solely used for research. The published results do not disclose the identity of individuals or organizations involved. All procedures adhere to the principles of "respect, voluntariness, and confidentiality".

4. RESEARCH RESULTS

4.1. Characteristics of the survey sample

The study surveyed 320 students across four major training institutions: Hanoi University of Science and Technology, Hanoi University of Industry, Ho Chi Minh City University of Technology and Education, and Vinh Long University of Technical Education. These institutions have a long history of training in mechanical engineering—specifically automobiles—and are located in the North, South, and Southwest regions, providing a comprehensive view of automotive engineering training in Vietnam. A total of 296 valid questionnaires were collected, resulting in a response rate of 92.5%.

The gender characteristics of the survey sample clearly reflect the industry traits: only 27 female students (9.1%), with the remaining 269 male students (90.9%). This ratio indicates that the automotive industry remains male-dominated, but the presence—though modest—of female students also points to a potential research area in gender diversity within technical training.

Regarding the academic year, 99 second-year students (33.4%), 92 third-year students (31.1%), and 105 final-year students (35.5%) participated in the survey. This setup enables the comparison of changes in cognition based on the learning process. In terms of school distribution, Hanoi Polytechnic students had the highest proportion (30.7%), followed by Hanoi Industry (26.4%), Ho Chi Minh City Science and Technology Institute (25.3%), and Vinh Long SPKT (17.6%).

Table 1. The information of the survey form (N = 296)

Character	N	Rate (%)
Male	269	90.9
Female	27	9.1
Second-year students	99	33.4
Third-year students	92	31.1
Fourth-year students	105	35.5
Hanoi University of Science and Technology	91	30.7
Hanoi University of Industry	78	26.4
Ho Chi Minh City University of Technology and Education	75	25.3
Vinh Long University of Technology and Education	52	17.6

Thus, the survey sample ensures a balance of training schools, school years, and regional representatives, while accurately reflecting the specific gender makeup of the automotive industry.

4.2. Students' perception of electric vehicle technology

The level of understanding of the key components of electric vehicles is an important measure for assessing training effectiveness. The results showed that most students only achieved an average score (2.4–3.4/5). Electric motors are the most familiar area, with an average score of 3.4, while high-voltage safety is the least known (2.4).

Table 2. Students' level of understanding of EV technology (Likert 1–5)

Items	Mean	SD
Battery and BMS system	2.7	0.94
Electric motors (PMSM/BLDC)	3.4	0.85
Chargers and charging infrastructure	2.8	0.89
High Voltage Safety	2.4	0.96
Regenerative braking system	3.1	0.81

When examined by school year, 4th-year students have slightly higher average scores than 2nd and 3rd-year students, but the difference is not statistically significant. For example, the 2nd-year students' battery and BMS understanding level is 2.6; 3rd-year is 2.7; 4th-year is 2.9. This indicates that the training program has not resulted in significant growth in EV content during the learning process.

Among schools, Hanoi Polytechnic students achieved the highest average score of 3.2, followed by HCMC Science and Technology University. Ho Chi Minh City ranks second with a score of 3.0, Hanoi Industry with 2.9, and Vinh Long SPKT has the lowest score at 2.8. This difference partly reflects variations in facilities and the level of investment in EV research by each school.

4.3. Students' expectations of post-graduation competencies

Students are asked to evaluate the importance of different competency groups. The results show that EV technical skills are rated highest at 4.7 out of 5, followed by digital competence at 4.4 and sustainable thinking at 4.1. Soft skills at 3.9 and foreign languages at 3.7 are lower but still considered high.

Table 3. Students' expectations for the post-graduation competency group

Items	Mean	Rank
EV technical skills (battery, BMS, motor)	4.7	1
Digital capabilities (AI, IoT, big data)	4.4	2
Sustainable thinking (recycling, environmental)	4.1	3
Soft skills (teamwork, presentation)	3.9	4
Specialized Foreign Languages	3.7	5

The detailed analysis showed small gender differences: female students (9% of the sample) rated higher in soft skills (4.3) and foreign languages (4.1) compared to boys (3.8 and 3.6). Although a minority group, female students' views reflect a tendency to value communication and international integration.

According to the school, students from Hanoi Polytechnic and Ho Chi Minh City University of Technology. Ho Chi Minh City scores higher in digital competencies than the other schools, while students at Hanoi Industry and Vinh Long Vocational Education emphasize soft skills and sustainable thinking more. This indicates differences in training focus and learning culture among these educational institutions.

4.4. Evaluation of current training programs

This section compares the current program and EV training needs. Currently, internal combustion engines still account for 42% of credits, while EV modules account for only 4%. Students and faculty alike believe that this ratio needs to be adjusted drastically.

Table 4. Comparison of Current Program Structure and EV Demand

Items	Situation (%)	Demand (%)	Compare
Internal combustion engines & mechanical transmissions	42	20	-22
Basic Electrical – Electronics	19	15	-4
Battery, BMS, electric motor, inverter	4	25	+21
High Voltage Safety	0	10	+10
Digital skills, IoT, AI	2	15	+13
Practice, capstone project	24	15	-9
Soft & Sustainable Skills	9	10	+1

Notably, students of Hanoi Polytechnic and Ho Chi Minh City Science and Technology Institute. Ho Chi Minh City believes that it is necessary to sharply increase EV modules, while Vinh Long SPKT students are more interested in capstone projects associated with businesses. This shows the difference in the development context of each school.

4.5. Views of lecturers and businesses

The results of interviews with 24 lecturers and 12 businesses reveal a strong consensus regarding the gap in the current program. The lecturer noted that the absence of EV labs is a significant obstacle. A lecturer at Hanoi Industry mentioned: "Students only learn about BMS on the slide, never disassemble a real battery module."

The business emphasizes high-voltage safety. A representative from a company in Ho Chi Minh City said: "We had to stop the project because the new engineer was not allowed to touch the battery because he had not been trained in HV safety." In addition, digital capacity is also a major issue. A manager at Thaco affirmed: "Electric vehicles are a combination of mechanics, electronics, and data. If engineers don't have the ability to analyze sensor data, they're going to fall behind."

4.6. Aggregate analysis and proposal of a new program framework

Data collected from students, lecturers, and businesses consistently shows that the current program does not meet the demands of the electric vehicle era. Three main gaps were identified: (i) lack of comprehensive EV modules, (ii) insufficient focus on high-voltage safety, and (iii) limited digital capabilities.

The study introduces a new program framework, decreasing the share of internal combustion engine modules from 42% to 20%, increasing the EV module to 25%, and adding new subjects.

Table 5. Recommended training program framework

Module Groups	New Modules	Credits	Form
Industry Base	Power Electronics for EVs	3	Theory + Lab
Specialized	Battery and BMS	3	Theory + Practice
Specialized	Electric motors & inverters	3	Theory + Lab
Safe	High Voltage Safety	2	Practice + case study
Application	Capstone project EV	5	Coordinating enterprises

In particular, the capstone project related to EV businesses will help students gain real-world experience early, reducing the gap between education and the marketplace. Additionally, the module on "Circular economy and battery recycling" is also recommended to meet the goals of sustainable development.

An analysis of data from four universities shows a consistent trend: Vietnam's automotive engineer training program remains heavily focused on internal combustion engines, while EV modules are nearly absent. Students have limited knowledge, especially about BMS and high-voltage safety. Lecturers lack the proper facilities for instruction, and companies are forced to retrain newly graduated engineers.

The new program framework is designed to strengthen the EV module, enhance digital capabilities and sustainable skills, and closely align with businesses. If adopted, this model will help Vietnam train the next generation of automotive engineers to meet global standards and support the green development strategy.

5. CONCLUSION

In the context of the global shift toward green transportation, especially electric vehicles, Vietnam cannot afford to be on the sidelines. Research from four major training institutions shows that the current automotive engineer training program still focuses heavily on internal combustion engines and has not kept pace with the trend. With EV modules making up only about 4% of total credits, students typically have an average or limited understanding of key areas such as batteries, battery management systems (BMS), and high-voltage safety. This explains why it takes an additional 6-12 months for businesses to retrain new graduates before they can participate in real projects.

Research also shows that students are highly aware of the labor market requirements. They ranked EV technical skills as the most important, followed by digital capabilities and sustainable thinking. Lecturers and businesses also agree, highlighting that EV labs, high-voltage safety modules, and engagement with businesses are essential for improving training quality. The close connection between students, lecturers, and businesses indicates that the pressure and need to innovate the program are ongoing and urgent.

Theoretically, this study adds empirical evidence on the challenges of engineering education during the energy transition. It clarifies the connection between program content, teaching methods, and competency outcomes, while emphasizing the importance of digital technology, sustainable thinking, and interdisciplinary skills in modern engineering education. This finding also proposes a theoretical framework for future research on STEM education within the context of green industry and Industry 4.0.

In practical terms, the study proposes a new training program framework with clear adjustments: reducing the proportion of internal combustion engines from 42% to 20%, increasing the EV module to 25%, and adding mandatory subjects such as "Batteries and BMS," "Electric Motors and Inverters," "High Voltage Safety," and "Power Electronics for EVs." In particular, the capstone project in collaboration with EV businesses is seen as an effective way for students to gain real-world experience, narrowing the gap between training and the market. Additionally, the inclusion of modules on circular economy and battery recycling demonstrates a commitment to aligning education with national sustainable development goals.

However, the study has some limitations. First, the survey was only conducted at four universities, which are representative but do not cover the entire automotive engineer training system in Vietnam. Second, the data was mainly collected from questionnaires and interviews, so there is no long-term vertical monitoring to truly assess the impact of the new program if implemented. Third, the proposed new program framework remains at the theoretical level and needs to be validated through practical pilots and quantitative evaluation of its effectiveness.

The next focus of research could be on developing a pilot EV program at selected training institutions, using both quantitative and qualitative assessments to evaluate its effectiveness. Simultaneously, it is important to broaden the scope of research to include vocational training centers, colleges, and short-term training courses to better address the varied demands of the labor market. An additional vital area is investigating gender inclusion in the automotive sector, as the current percentage of female students is only about 9%, revealing a significant gap in policy and support.

In conclusion, the study has confirmed that evolving the automotive engineer training program toward electric vehicle technology is an essential requirement in the context of globalization and sustainable development. If implemented together, the new program will not only help Vietnam train a generation of engineers capable of international integration but also support the achievement of national strategic goals on green energy transition, emission reduction, and sustainable economic growth.

REFERENCES

[1] Basri, A. Q. (2025). A potential electric vehicle curriculum development. Cogent Education.
[2] Bonnema, G. M. (2025). Electric Vehicle System Design Course—Implementing. World Electric Vehicle Journal, 16(8), 475.
[3] Chau, K. T. (2025). Graduate Degree in Electric Vehicles—A Timely Programme. World Electric Vehicle Journal, 16(1), 31.
[4] Hayes, J. G., et al. (2021). Global Perspectives on Electric Vehicle Education: Part I. EEDS 2021.
[5] Hayes, J. G., et al. (2021). Global Perspectives on Electric Vehicle Education: Part II. EEDS 2021.
[6] McDonald, D. (2010). Engineering & technology education for electric vehicle development. ASEE Annual Conference.
[7] Minaie, A. (2025). Electric vehicles in electrical and computer engineering programs. ASEE Annual Conference.
[8] Bonnema, G. M. (2025). Electric Vehicle System Design Course (PDF version). World Electric Vehicle Journal.
[9] Chau, K. T. (2025). Graduate Degree in EVs (Alt index). DOAJ.
[10] Saleet, H., et al. (2023). Importance and barriers of establishing educational programs in EV/HEV. World Electric Vehicle Journal, 14(9), 232.
[11] Chau, K. T. (2025). Translation of electric vehicle research into education. World Electric Vehicle Journal, 16(6), 327.

[12] Chau, K. T. (2025). Translation of EV Research into Education (Preprint). ResearchGate.
[13] Martínez-Borreguero, G., et al. (2024). Integrating energy & sustainability into the educational curriculum. Sustainability, 16(10), 4100.
[14] Frontiers in Education. (2022). Curriculum development for student agency on sustainability. Frontiers in Education, 7, 871102.
[15] Vallée, M. (2024). Environmental literacy requirements in US universities. International Journal of Sustainability in Higher Education, 25(9), 60–74.
[16] Grauer, C. (2022). Time and sustainability: A missing link in formal education. Journal of Environmental Education, 53(3), 212–228.
[17] Leal Filho, W., et al. (2008). Developing a whole-of-university approach to educating for sustainability. International Journal of Sustainability in Higher Education, 9(3), 239–250.
[18] MDPI Sustainability (Special Issue). (2024). Sustainability in higher education: Curriculum design & pedagogy. Sustainability.
[19] Cleaner Production. (2024). Transformative organisational learning for sustainability in higher education institutions. Journal of Cleaner Production, 432, 1410825.
[20] International Journal of Sustainability in Higher Education (IJSHE). (n.d.). Aims & scope.
[21] Liao, G. Y. J. (2016). Learning tool for lithium-ion battery management system. ASEE Annual Conference.
[22] Judge, G., et al. (2022). Sociotechnical module on EV batteries in circuits course. ASEE Annual Conference.
[23] Steger, F., et al. (2020). Teaching battery basics: Hands-on versus simulated experiments. HAW Munich.
[24] Steger, F., et al. (2020). Teaching battery basics (Abstract). ResearchGate.
[25] Research Publish. (2020). Design of battery management system (educational project). International Journal of Engineering Research & Technology.
[26] Bergveld, H. J. (2001). Battery management systems: Design by modelling. University of Twente.
[27] Chen, K. (2007). Building a modern power electronics & electric machines lab. ASEE Annual Conference.
[28] Balog, R. S. (2005). Modern laboratory-based education for power electronics. IEEE.
[29] Virtual lab for power electronics. (2001). Web-based remote experiment. ResearchGate.
[30] SAE International. (2020). Fundamentals of high voltage xEV safety & PPE (Course C2001).
[31] iJAC. (2016). Clarification of the training requirements for working on EVs. International Journal of Advanced Corporate Learning, 9(2), 45–51.
[32] ResearchGate. (2016). Training requirements for working on EVs (Abstract).
[33] ASE Education Foundation. (2024). New HV/EV tasks, tools & training resources. https://aseeducationfoundation.org/uploads/NewHV-EVTasksandTrainingResources.pdf
[34] U.S. Department of Energy (DOE). (2013). Battery testing, analysis and design—Annual report. DOE Energy Storage Program.
[35] ASEE. (2025). EV weights & infrastructure in civil engineering courses. ASEE Annual Conference.
[36] ASPIRE/ASEE. (2025). From railroads to electrified roadways: Curriculum improvements. ASEE Annual Conference.
[37] ASEE. (2025). Integrating EV technology with AI in automotive engineering courses. ASEE Annual Conference.
[38] ASEE. (2024). Battery-powered vehicle model for elementary science curricula. ASEE Annual Conference.
[39] University of Michigan. (2024). EV lessons cruise into K-8 classrooms. CSE Michigan.
[40] SAE International. (n.d.). Ramp Up! The physics of EVs (K-12 suite).
[41] SAE International. (n.d.). Charge Up! The chemistry of EVs (K-12 suite).
[42] SAE International. (n.d.). Measure Up! The math of EVs (K-12 suite).
[43] SAE International. (n.d.). Electric Vehicles Challenge Suite (High School).
[44] SAE International. (n.d.). Hybrid & EV Engineering Academy (Professional upskilling).
[45] ASEE. (2025). Funding challenges for curriculum development for EV repair & maintenance. ASEE Annual Conference.
[46] ASEE. (2025). Funding challenges for curriculum development for EV repair & maintenance (PDF). ASEE Annual Conference.
[47] Purdue University & IUPUI. (1998). A new EE curriculum in electric vehicle applications. IEEE/ASEE.
[48] World Electric Vehicle Journal. (2024). Educational EV prototype—Design/fabrication review. WEVJ, 15(8), 354.
[49] Advanced Electric Drive Vehicle Education Program. (2015). Overview. DOE/WEVJ.
[50] ResearchGate. (2015). Advanced Electric Drive Vehicle Education Program (Overview).
[51] International Council on Clean Transportation (ICCT). (2022). Promoting the development of electric vehicles in Vietnam.
[52] Trung, N. T., et al. (2024). Determinants of electric two-wheelers uptake in Vietnam. Transportation Research Part A, 179, 103732.
[53] Nguyen, M. H., et al. (2023). Can electric buses entice more public transport use? Sustainable Cities & Society, 93, 104580.
[54] Nguyen, H. T. T. (2025). Overcoming barriers to EV adoption in Vietnam. SSRN.
[55] Pham, T. H., et al. (2024). Promoting EV consumption in Vietnam: An empirical study. ResearchGate.
[56] International Journal of Business & Social Science (IJBSS). (2023). Consumer intentions to adopt electric automobiles in Vietnam. IJBSS, 14(6), 112–124.
[57] Tran, L. H., et al. (2025). Actual behaviour in using EVs in Vietnam: Users' perspectives and the role of ride-hailing. ResearchGate.
[58] Skouras, T. A. (2020). Electric vehicles: Current state of the art, future perspectives & impacts. Machines, 2(1), 1.
[59] Alanazi, F., et al. (2023). Electric vehicles: Benefits, challenges & potential solutions. Applied Sciences, 13(10), 6016.
[60] Alatise, O., et al. (2025). Second-life potential of EV power electronics. Renewable & Sustainable Energy Reviews, 186, 113211.