Development of Learning Modules and Skills Mapping to Prepare Workforce Competencies for the Electric Vehicle Industry

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Abstract

The automobile industry has become a major role in both the global economy due to the rising cost of oil and increasing carbon emissions. Thai government has been promoting the next-generation automotive industry by focusing on expanding the current sector into more advanced technologies and innovations, alongside implementing significant measures to support electric vehicles (EVs). These initiatives will cover the development and strengthening of human capital for the working population, emphasizing lifelong skill development to align with the evolving labor market demands. This research aims to analyze the relationship between electric vehicle technology learning modules and occupations through skill mapping and to explore strategies for developing EV technology readiness curricula to meet future demands. The study invited experts from the automotive industry and related sectors for interviews and group discussions using the Delphi technique to create learning modules for EV technology that align with future needs. The research results demonstrate the connection between skill groups and learning modules, as well as the relationship between EV technology and learning modules. Finally, the study provides guidelines for a comprehensive learning management approach that addresses multiple dimensions of skills. The prototype module outlines battery design and assembly with defined objectives, learning outcomes, and learning management plans. This research serves as a pilot project for developing human resources in preparation for Thailand's emergence as a global leader in the electric vehicle industry.

Keyword : Learning modules, Skill map, workforce competencies, Electric vehicle

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Introduction

Nowadays, the issue of renewable energy is a matter of worldwide importance due to lack of people with knowledge and ability to solve problems. The energy resources that are used from things that come from nature in terms of using fossils will inevitably run out and will not be enough for consumers (United Nations, 2012; MDB Working group on Sustainable Transport, 2015). The most common use of fossil fuels is oil. The oil energy has been used for the use of machinery to produce electricity and the use of oil energy for vehicles such as trains and cars. Using this type of energy will cause environmental impacts, whether it's global warming from the greenhouse effect or the presence of PM2.5 dust particles, which affect health and the respiratory system, which humans are involved in causing all of these problems (Castro et al., 2017). It can be seen that the lack of knowledge and understanding of energy use is a major problem. The world's dependence on petroleum-based fuels needs to transform alternative fuel sources and a new means of transportation itself (Mehta & Modak, 2011; Jawalekar et al., 2020). The current alternative is to reduce the dependence on oil in the automotive industry by switching to electric power instead. The electric vehicles will play an increasingly important role in the global automotive industry and have the potential to grow further in the future.

The most important and effective human resource for energy saving policy is the personnel of the agency who have knowledge and ability and keep up with technology. Therefore, the development of knowledge and skills related to electric vehicles in terms of production, maintenance, as well as building infrastructure to support electric vehicle technology is necessary to develop personnel along with the growth of technology. Skills and competencies are not only basic concepts but also the foundation on which humans can improve the quality of their work. Improving human skills and abilities is essential for companies to maintain their competitive edge. The concept of future skills including reskilling, upskilling and new skills provides a great opportunity for the development of human skills and competencies, as well as adding new skills or competencies for human. Due to government support helping to help consumers have the ability to purchase electric vehicles, measures to reduce electric vehicle tax rates and providing subsidies for the purchase of electric vehicles (Tiprong & Chairatana, 2023), price of electric cars and establishment of charging stations to meet demand (Poolma & Rassameethes, 2021). They are related to the acceptance of electric cars, is a factor that promotes the use of more electric cars.

The government agencies in Thailand are taking proactive steps in various activities, including promoting education. The thirteenth national economic and social development plan (2023-2027) emphasizes the importance of developing the legacy automotive industry into modern vehicles while maintaining its potential as an important global automobile manufacturing base. Manpower is an important part in leading the country to reach the set goals, especially in the field of electric vehicles, which requires manpower with specialized potential both in the age group that will be a replacement manpower or new job development for the industry in the future and non-aged group is important personnel during the transition situation to new technology. What is currently found regarding the competency of personnel with knowledge and skills in energy saving and electric vehicle technology is still lacking. One reason for this is the lack of a skills map to map the relationship between learning modules on electric vehicle technology and career paths. However, electric vehicle work is a new job

which will lead to the emergence of new careers and require knowledge and skills that are very different from before. Then the benefit of planning the development of manpower in the field of electric vehicles, including the development of courses related to the field of electric vehicles to equip the manpower with knowledge and skills to be able to pursue a career in the field of electric vehicles. This is in line with the strategy according to the third goal of the production of electric vehicles of the thirteenth national economic and social development plan. In addition, the development of skills maps will collect and demonstrate the skills required for job positions and the skills that each curriculum will develop for learners to help in planning the country's human resources and designing curricula that truly meet the needs, which can be considered as a personnel development strategy.

This research aims to analyze the relationship between the learning modules of electric vehicle technology and career paths using skill mapping, and to study the curriculum development guidelines for preparing for electric vehicle technology to support future needs. It uses skill mapping, a method that visualizes all human skills, to create a human improvement strategy. The mapping skill is a visual representation created of all the necessary skills and competencies that human must have. It can be used to develop curricula and training courses that are tailored to the needs of each human being. This research was collected information on the careers and roles of each occupation, including the skills and knowledge required to pursue that career. The work was conducted in the form of interviews and data from the interviews were analyzed together with a literature review to determine focus groups for skill mapping. The information received may include the career, knowledge and skills required in order of importance. After that, it is analyzed the data, forecasted the results for the next 5 years and determined the recommendations for curriculum development, which may consist of degree programs or short courses. This research can develop a sample course to lead to a pilot in manpower development to prepare for the transition to becoming a country in the world's top electric vehicle industry.

Literature Reviews

1. Electric Vehicles

Electric Vehicle (EV) are a promising form of sustainable transportation. It usually refers to any vehicle that is powered, in part or in full, by a battery that can be directly plugged into the mains. It is a practical alternative to conventionally fueled vehicles if the production of electricity used is not polluting (Pichelmann et al., 2013). It can be divided into 4 types: i) Hybrid Electric Vehicle (HEV), ii) Plug-in Hybrid Electric Vehicle (PHEV), iii) Battery Electric Vehicle (BEV) and iv) Fuel Cell Electric Vehicle (FCEV) (Borirak, 2024). However, the electric vehicles have specific properties, however, that are novel for drivers of conventionally fueled vehicles. Many studies have focused on various service operations issues that are considered important in driving the growth of the EV industry. For instance, how innovative business models might succeed long-term, how governments should encourage the EV market through incentive programs, and how charging infrastructures can be built to satisfy consumer needs while minimizing social costs (Dominković et al., 2018; Lv & Shang, 2023). (Charoenthongthae 2023) studied about becoming a business owner of an electric vehicle charging point in Thailand because the number of electric cars in Thailand is increasing every year. This research is focus on the electric vehicles, low carbon society, measures to promote electric vehicles in Thailand, and the electric vehicle charging point

business in Thailand. (Jarasrungchawalit & Kasikitwiwat, 2023) simulated the electric charging stations under the situation of analysis and evaluation service levels using queuing theory. However, method of damaged batteries management for electric vehicles is necessary. (Borirak. 2024) presented a model for managing batteries for electric vehicles that have reached the end of their life and are recycled. If the battery comes from a normally used electric vehicle, additional testing will be done to ensure that the battery has some life left and is still functioning and safe.

2. The 13th National Economic and Social Development Plan

The 13th National Economic and Social Development Plan (2023-2027) mentioned that Thailand is the World's Important Electric Vehicle Manufacturing Base. It is being ASEAN's number one and the world's 11th biggest automobile manufacturer/ exporter in 2019 with a total export value of 1,300,561 million baht. However, the world's automotive demands are shifting towards electric vehicles (EVs) partially due to advanced battery technologies, which lower prices and increase the efficiency of electric vehicles, in addition a global trend towards low-carbon societies. The Thai government has promoted the next-generation automotive industry by emphasizing an expansion of the current industry onto more advanced technology and innovation together with determining key supportive measures for EVs by supporting the development of nationwide infrastructure, particularly charging stations. The goals of Thailand's EV industry development acceleration is in three areas including 1) To increase domestic consumption and export demand for all types of EVs, 2) To encourage existing operators to shift to EV production, and to support key technology investment in domestic EV production and 3) To build an ecosystem of supporting factors. The aim is to achieve the targets set by the National Electric Vehicle Policy Committee and to effectively mitigate environmental impacts. The developed goals for connections between Milestone 3 and the main targets and goals of the 13th National Economic and Social Development Plan and the National Strategy are 1) restructuring the manufacturing and service sectors towards an innovation-based economy, 2) Developing human capital for the future and 3) Transitioning production and consumption towards sustainability. For the working-age population, emphasizes lifelong capacity building with continuous enhancement of capacity, skills, and competency of the workforce in line with the labor market's needs.

3. Skill Mapping

Skill mapping refers to the process of identifying and documenting the skills that are present within a team, department, or organization. It helps match the skills of individuals with the requirements of their roles, as well as identify any gaps in skills that might need to be filled. It is a visual representation of all the skills employees have within a department or organization. It involves analyzing each employee's competency related to a particular skill, especially abilities that relate to specific projects, roles and tasks. This technique allows you to understand the abilities of employees and the value that each of them provides. It can reveal the strengths and weaknesses of each employee. The skills mapping is a strategic tool that enables organizations to comprehensively assess and understand their workforce's capabilities. By identifying and documenting the skills of individuals across various roles, skills mapping provides valuable insights into an organization's existing competencies and potential gaps. This process allows organizations to better align their human resources with business objectives, identify areas for improvement, and guide targeted training, development, and recruitment efforts. Ultimately, skills

mapping helps organizations enhance performance, optimize talent deployment, and ensure the workforce is equipped to meet both current and future challenges. It can be a personalized approach to assessing and enhancing learner competencies (Touis et al., 2023). It can map skills and analyze skill gaps of employees of a manufacturing organization (Rajvaidya, 2022).

Methodology

This research was collected information on the careers and roles of each occupation, including the skills and knowledge required to pursue that career using Delphi Technique. It is a structured method for gathering expert opinions and reaching a consensus on a specific topic or issue. This research was conducted in the form of interviews and data from the interviews were analyzed together with a literature review to determine focus groups for skill mapping and lead to demand forecasts for the next 5 years. The mapping skill is a visual representation created of all the necessary skills and competencies that human must have. It can be used to develop curricula and training courses that are tailored to the needs of each human being. The information received include the career, knowledge and skills required in order of importance. Then, the results of determining the sequence of occupational needs that are expected to be important in the next 5 years will lead to the determination of recommendations for curriculum development, which may consist of degree programs or short courses. This research studied the development of human skills and competencies that is under the electric vehicle production that consists of three main parts, consisting of the first part which is the parts and production of electric vehicles, which includes main parts such as electric motors, batteries, etc., and minor parts to assemble the vehicle or additional components. The second part is the infrastructure and charging system. The third part is maintenance and modification of electric vehicles as shown in Figure 1.

This information will then be used to develop a sample course to lead to a pilot in manpower development to prepare for the transition to becoming a country in the world's top electric vehicle industry.

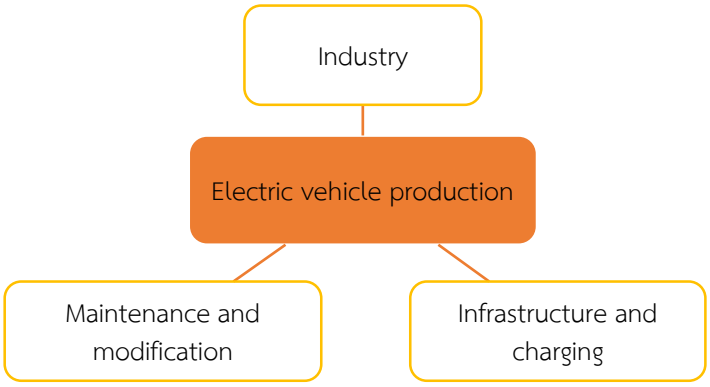

Figure 1 The Electric Vehicle Production

Results

1. Job Analysis

This research would like to draw on the abilities of experienced people to analyze roles and duties as well as career paths that may occur in the electric vehicle industry of Thailand in the future, in-depth interviews and search for such features. It started with interviews with people in the automotive industry, including i) electric vehicle maintenance, ii) electric charging stations, and iii) electric vehicle production industry, who are involved in creating basic career competencies related to electric vehicles. Then, they are organized a focus group meeting to find guidelines for creating a module for learning about electric vehicles. The skill and knowledge can identify as:

- Electric vehicle maintenance: Most of the knowledge is electrical and electronic engineering work required for basic maintenance and maintenance, understanding the structure and mechanical basis of automobiles, expanding knowledge on the electricity, electronics and computer programs, and basic knowledge of safety, legal procedures and regulations for work. The necessary skills are thinking, analyzing problems and communication for coordination with both customers and co-workers.

- Electric charging stations: The necessary knowledge is about working with high voltage electricity, assessment of the installation location, investment, the pattern of program for creating communication between electric charging stations and cars. Moreover, human should have basic knowledge and skills in understanding the components of batteries.

- electric vehicle production industry: Most of the automotive manufacturing industry receives structural designs or automotive parts that have production prototypes from overseas. Then, humans should have the basics in manufacturing, designing production processes and learning about the materials and equipment that will be used to produce electric vehicle parts. The important skills are the use of technological tools in designing, learning about computer programs to understand the basics of using the internal communication system of electric vehicles, skills in molding work and skills in analytical thinking.

From the above information, it can be analyzed into groups of skills to be used as a guideline for creating learning about electric vehicle technology in order to cover the skills to be able to learn in all aspects as shown in the Table 1.

Table 1 Skills of Electric Vehicle Technology

Order	Skill	Meaning
1	Structure and transmission system	Design structures, assembly systems, and power transmission systems in electric vehicle systems to be safe according to standards set for electric vehicles, analyze and inspect problems.
2	Battery systems for electric vehicles	Design and build battery systems, Managing battery operation and heat for safety

Table 1 Skills of Electric Vehicle Technology (Continue)

Order	Skill	Meaning
3	Designing storage systems, equipment, control systems and displays	Design data storage systems, select equipment and various systems. To be able to work together and develop programs for controlling and monitoring the operation of the system.
4	Charger work system in electric vehicle systems	Design/build electric vehicle chargers and plan the installation and maintenance of charging station systems to ensure safety.
5	Installation and test	Integrate all electric vehicle systems to work together and assess the safety of electric vehicles, electric vehicle modifications, and charging systems according to regulations, laws, international standards, and Thai standards.
6	Maintenance and troubleshooting	Maintain structural systems, assembly systems, and transmission systems in electric vehicles according to standards.
7	Safety	Design/ construct and evaluate system structures in electric vehicles according to specified safety standards.

2. Topic Analysis

After the focus groups meeting and in-depth Interview, data has been taken from an analysis of the needs of various areas related to automotive technology. After that, a prototype module was created for learning and creating expertise in electric vehicle technology, which is as follows.

- Module 1: Basic Electrical Engineering and Installation
- Module 2: Automotive Technology
- Module 3: High Voltage (Operation and Standard)
- Module 4: Motor Technology (Maintenance and control, Thermal Management)
- Module 5: Battery Design (Pack/Re-pack, Operation Control, Thermal Management)
- Module 6: Inverter and Converter for EV Technology
- Module 7: Charging Technology (Onboard, Charging Station, Testing)
- Module 8: Autonomous
- Module 9: Programming (GUI, Dashboard, System Integration)
- Module 10: Embedded System (Hardware and Software)
- Module 11: Sensor, Interface and Communication Standard
- Module 12: Vehicle Monitoring and Control
- Module 13: Material and Production and Conversion
- Module 14: Regulation and Standard (Safety)

Each skill has its own competencies under related with learning module. To analyze the data, it was found that there was a relationship between expertise and career characteristics related to electric vehicle technology. The nature of this expertise also has some relationship with the nature of the learning modules, as shown in the Sankey Diagram in Figure 2. The system integration is linked to a maximum of 11 modules. The next skills that linked module are electric charging station management, structure and assembly system design, battery assembly, powertrain management and control, future vehicles, cooling system management, system testing and security management, respectively. On the opposite side, it can be seen that module 11 (sensor, Interface and communication standard) is associated with the largest number of skills.

To consider in-depth, the above professions by considering at the various systems that are necessary for automotive technology that corresponds and covers all 3 areas, including electric vehicle maintenance systems, installation of electric charging stations, and the automotive parts manufacturing industry, they are divided into aspects including safety, charging systems, battery systems, structure and power transmission, and integration of electric vehicles. The linkage of the modules can be seen in how each aspect is related to electric vehicle technology as shown in the Sankey Diagram in Figure 3.

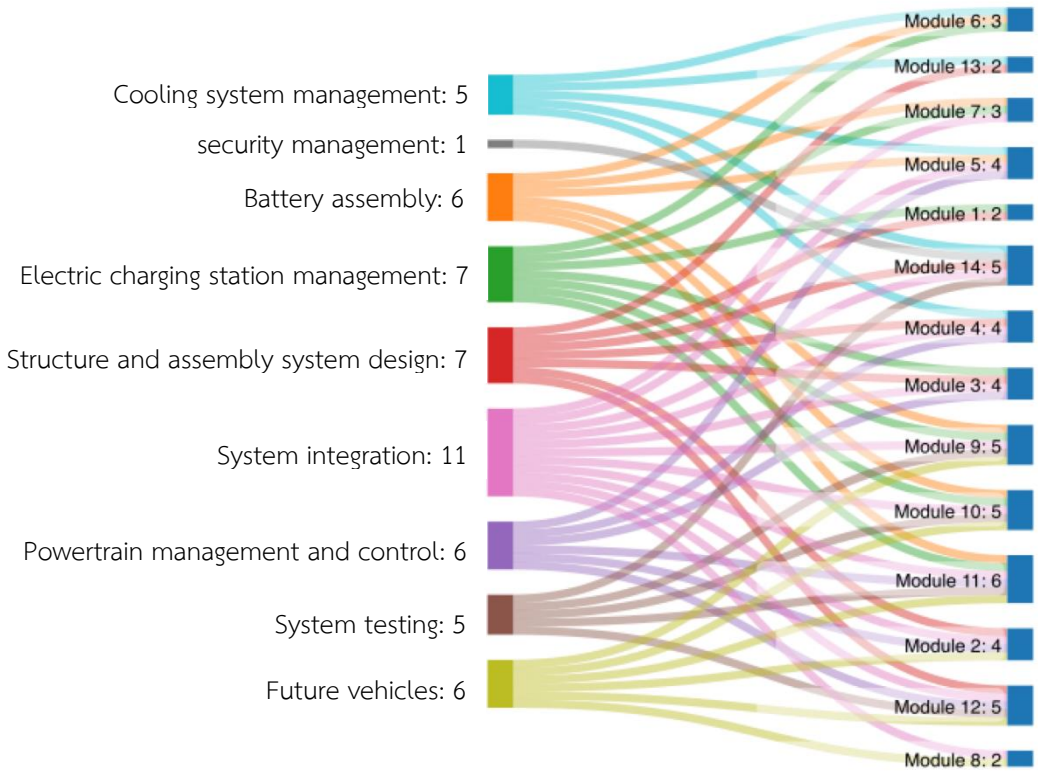

Figure 2 Relationship of Skill Groups to Learning Modules

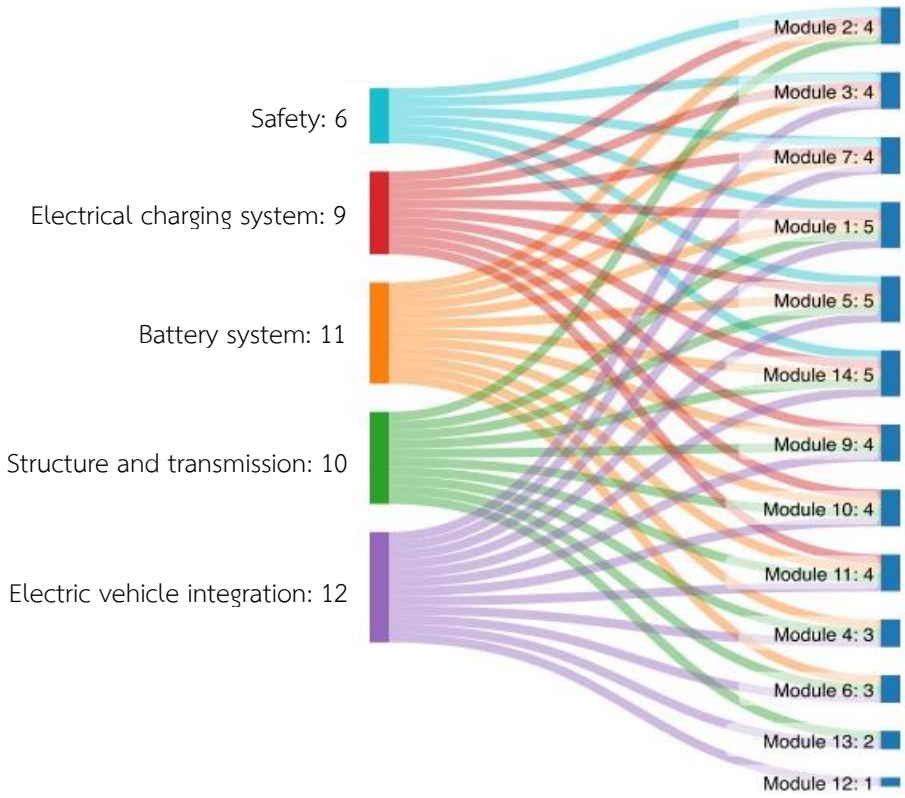

Figure 3 Relationship of Areas Related to Electric Vehicle Technology to the Learning Modules

3. Learning Modules on Electric Vehicle Technology

According to brainstorm ideas on creating knowledge that is necessary for the future manpower to support work in electric vehicle technology, a set of technology learning modules (14 modules) has been created the electric vehicles with learning management guidelines that are consistent and comprehensive with skills in various areas. In each module will be elements of competencies that learners should acquire, desired skills, course descriptions and plan for implementing the learning modules that are consistent with building skills in electric vehicle technology.

The research selected Module 5, battery design and assembly, as a prototype module or sample learning module, and the results of these prototype modules can be used for further development. The reason for selecting this module is because it is a battery pack design and assembly designed to improve the performance of electric vehicle personnel and can be used to increase the capacity of unemployed people or those who want to improve their EV competency and new graduates. The objectives are to transfer the basic knowledge of electric vehicle (EV) battery technology and working principles of battery management systems and raise the level of labor competency in battery design for electric vehicles and testing according to standards. The learning outcomes are creating personnel that are in line with desired skills in electric vehicle technology as shown in Figure 4.

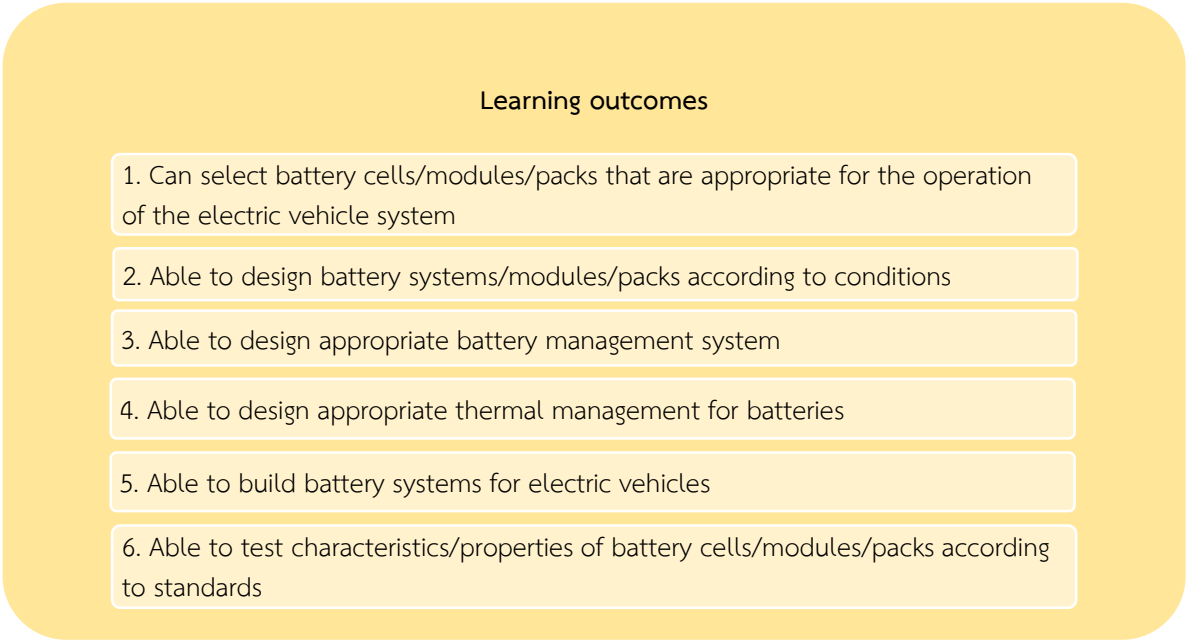

Figure 4 Learning outcome on Module 5 Battery Design and Assembly

The content of this topic is divided into 5 sub-modules including 1) battery technology 2) battery management system 3) thermal management 4) battery assembly and 5) electric vehicle battery testing. The number of hours is divided into 42 hours for lecture, 101 hours for workshops and 142 hours for work in the workplace. Plan for managing learning modules on battery design and assembly is shown in Table 2.

Table 2 Plan for Managing Learning Module on Battery Design and Assembly

Sub-module	Number of hours			Skills to receive
	Lecture	Workshop	work in the workplace	
1. Battery technology	7	7	14	- Use tools to measure/ analyze battery cell characteristics. - Test for specific battery cell characteristics
2. Battery management system	21	14	35	- Consider the installation points for electric cars - Calculate load and select cells in line with needs and conditions - Calculate and design battery modules - Manage the battery system
3. Thermal management	7	7	14	Design a cooling system for the battery

Table 2 Plan for Managing Learning Module on Battery Design and Assembly (Continue)

Sub-module	Number of hours			Skills to receive
	Lecture	Workshop	work in the workplace	
4. Battery assembly	7	45	51	- Install fire insulation, heat management systems, control equipment, signal cables and leads in the battery pack. - Measure the resistance of the battery - Install battery management system - Electrical and working tests
5. Electric vehicle battery testing		28	28	- Insulation Test (HIPOT Test) - Battery module/pack test
Sum	**42**	**101**	**142**	

Conclusion and Discussion

Due to the electric vehicle technology will play a growing role in Thailand, then, personnel must be developed to support and respond to the upcoming electric vehicle technology in terms of production, maintenance and infrastructure. This research aims to find the relationship between learning module on electric vehicle technology and careers using skill mapping under considering the human skills and competencies, and develop a sample course to prepare for the transition generation. It started collecting information from the interviews and to determine focus groups for skill mapping. The data is covered on the careers and roles of each occupation, including the skills and knowledge required to pursue that career. The data is analyzed and determined the recommendations for curriculum development as 14 learning modules that are consistent and comprehensive with skills in various areas for the electric vehicle technology. In each module will be elements of competencies that learners should acquire, desired skills, course descriptions and plan for implementing the learning modules that are consistent with building skills in electric vehicle technology. This research selected module 5 that is about battery design and assembly, as a prototype module or sample learning module. It identifies the objective, learning outcomes and plan for managing learning module. Then, this research is considered a starting point to lead to a pilot in manpower development to prepare for the transition to becoming a country in the world's top electric vehicle industry.

Nanthakorn et al. (2024) focus on the life cycle management of EV battery packs, such as repair, reuse, refurbishment, remanufacturing, and recycling. This research aims to explore future challenges and opportunities for such strategies in the market in Thailand and to evaluate them from an economic, ecological, and technical perspective. As well as, Nukitrangsan & Chomsuwan (2023) designed and created the skill maps for factory electricians, using skill mapping to create training courses that are suitable for employees' requirements, and evaluating the skills and competencies of employees.

Sangchan et al. (2022) proposed a practical learning model or 4MAT model to reduce downtime in the process and to develop the problem-solving abilities of technicians through experimental learning process based on 21st century skills requirements. Moreover, Baldissera & Delprete (2014) studied on human powered vehicle (HPV) design for a challenge for engineering education by student team challenges as efficient ways to stimulate students' independent work, technical and management learning as well as socialization and internationalization. The main returns for student challenge are: better understanding of the sustainable mobility problem, awareness about the potential and the limits of human muscular power, development of technical skills about design and engineering of lightweight and efficient vehicles, stimulation of the HPVs market development, promotion of healthy and engaging physical activities.

Recommendation for Future Research

For this research is a starting point of learning module as prototype module on battery design and assembly of the electric vehicle technology. There are still 13 modules remaining to develop curricula and training courses that are tailored to the needs of each human being. The remain modules are 1) basic electrical engineering and installation, 2) automotive technology, 3) high voltage, 4) motor technology (maintenance and control, thermal management), 5) inverter and converter for EV technology, 6) charging technology (onboard, charging station, testing), 7) autonomous, 8) programming (GUI, dashboard, system integration), 9) embedded system (hardware and software), 10) sensor, interface and communication standard, 11) vehicle monitoring and control, 12) material and production and conversion and 13) regulation and standard (safety).

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