Learning Outcomes in Electric Vehicle Technology: Competency-Based Learning Management According to the TVET Curriculum

Akkarat Poolkrajang[1], Rinradee Papanai[2*]
[1,2]Faculty of Technical Education, Rajamangala University of Technology Thanyaburi, Khlong Luang, Pathumtani, 12120, THAILAND
[1]akkarat_p@rmutt.ac.th [2]rinradee_p@rmutt.ac.th

***Abstract*—Automotive technology is changing rapidly and will fully enter the electric vehicle industry in the future. The teaching and learning management that emphasizes learning outcomes in electric vehicle technology is important to prepare learners for future labor market needs. This will result in high-quality learning management, which in turn will yield high-quality results. This research uses a research and development model. The informants to study the components and develop the model include administrators and teachers, and the groups of informants to evaluate the model. The research instruments used were interview forms and opinion assessment forms. The research results found that the components of electric vehicle technology teaching and learning include teachers, students, professional content, learning plans, teaching in the electric vehicle technology field, preparation of teaching media and equipment, and evaluation of learning outcomes. There are three parts to teaching and learning management that focus on learning outcomes in the field of electric vehicle technology. Part 1 is getting ready for teaching and learning, Part 2 is planning teaching and learning activities, and Part 3 is constantly improving and evaluating the teaching and learning model that focuses on learning outcomes in the field of electric vehicle technology. The overall level of opinion is at the highest level. In summary, teaching and learning management emphasize quality learning outcomes and the development of students to have high competence to meet the needs of electric vehicle technology establishments in Thailand.**

***Keywords*—Learning Management, Learning Outcomes, Electric Vehicle Technology, Vocational Education Curriculum, Competency-based Learning**

***JEET Category*—Research**

I. INTRODUCTION

The automobile sector in Thailand plays a crucial role in its economic progress, as it experiences substantial international demand and serves as a catalyst for economic expansion (Anis F. M. Z. et al., 2012). The sector is constantly changing due to increased rivalry and the expansion of market-driven production (Isak, 2016). Technical advancements increasingly influence the progress of this development (Schulze A. et al., 2014). Notably, the advancement of electric vehicle (EV) technology is in line with Thailand's economic goals under the Thai 4.0 economic model, which aims to achieve high-income status by 2036 AD. Thailand's automotive sector is not only a regional production powerhouse; it also placed 12th globally in automotive production in 2016 AD. It stood alongside major players such as China, the United States, Japan, and Germany and produced 1.94 million vehicles. At the same time, the total value of automotive product exports amounted to 923,377.6 million baht, with a workforce of over 750,000 people spread across 1,600 enterprises. Thailand, on the other hand, faces challenges such as a slowdown in vehicle manufacturing due to heightened competition in the region, particularly from countries like Indonesia. In addition, the automotive sector is facing a transition towards electric vehicles (EVs) while also maintaining a high level of expertise in internal combustion engines (Thailand Automotive Institute, 2012). Electric vehicles (EVs) and hybrid vehicles are considered potential options due to the increasing need for alternative energy sources (Wael A. S. et al., 2019).

Strengthening labor skills and competencies is crucial for national competitiveness, requiring a focus on improving core knowledge and enhancing skills. This encompasses the development of skills such as critical thinking, innovation, resolving complex issues, making informed choices, collaborating effectively, considering ethical implications, demonstrating self-control, adapting to technological

Rinradee Papanai
Faculty of Technical Education, Rajamangala University of Technology Thanyaburi, Thailand
rinradee_p@rmutt.ac.th

advancements, and having a willingness to continuously learn throughout one's life. Vocational education and training are essential in shaping a workforce that is well-suited to adapt to changes in the economy and technology. According to the Vocational Education Act of 2008, education is a continuous and ongoing activity. The government should implement focused methods and curriculum reforms to enhance the skills and capacities of both skilled and semi-skilled workers (Muhd K. O. et al., 2020). Programs that produce skilled individuals with knowledge, a competitive advantage, creativity, innovation, and alignment with industry requirements are crucial (Hassan et al., 2013). Thailand's vocational human resource development necessitates a transition from a training approach centered on maintenance to one that focuses on imparting knowledge and expertise in production. According to Teravuti, B. (2010), students should demonstrate a diligent and dedicated approach to their jobs, acquire hands-on experience in a professional setting, and utilize available resources to enhance productivity. It is also important for the education system to have significant industry participation in managing and overseeing the educational process. The Ministry of Education has implemented policies to raise vocational education standards to meet global benchmarks. These policies focus on developing vocational certification frameworks, improving the quality of teaching to align with the labor market demands, and expanding student enrollment in vocational programs. However, the general caliber of graduates frequently lacks crucial job skills, exacerbating the problem of unemployment

Efficient instructional administration is critical, especially in complex industrial vocational courses where comprehension may be difficult. Conventional instructional approaches frequently prioritize memorization through repetition rather than active engagement, analytical thinking, and autonomous problem-solving, resulting in below-average academic achievements. To improve the quality of teaching, it is crucial to emphasize the significance of adjusting teaching methods to correspond with the needs of the industry. This will aid in developing a workforce that meets the needs of businesses and promotes global competitiveness. To improve the quality of the workforce and ensure that they possess the necessary skills that align with the actual requirements of the business sector, it is important to provide them with opportunities to attain higher professional qualifications and compete on an international level. This will ultimately create a comprehensive and sustainable professional environment (Umnapiang, P., 2022).

Thai vocational institutions, particularly those emphasizing electric vehicles (EVs), prioritize a combination of theoretical instruction and practical application. These institutions use contemporary teaching methods that are in line with the most recent advancements in automotive technology. Partnerships with government entities, commercial enterprises, corporations, and organizations are facilitating the creation of educational programs, determining educational tasks, and evaluating the results of professional training, finally creating graduates who fulfill specific industry requirements. The objective of this research is to examine the various aspects of teaching management that focus on improving learning outcomes in the field of electric vehicle technology. It also aims to devise teaching strategies that can effectively enhance these outcomes. Furthermore, the research intends to evaluate the usefulness of these strategies within Thailand's vocational curriculum. This undertaking holds the potential for significant national progress, as it aligns with the government's plan to meet the manpower demands of the automotive industry, thereby guaranteeing a steady stream of job possibilities for graduates.

II. CONCEPTUAL FRAMEWORK

From studying information, principles, concepts, theories, and various research works related to research issues such as the evolution of curriculum and teaching methods in TVET, outcome-based learning, teaching and learning management plans in the field of electric vehicle technology. Therefore, this is summarized as the conceptual framework for this research. As shown in Fig. 1.

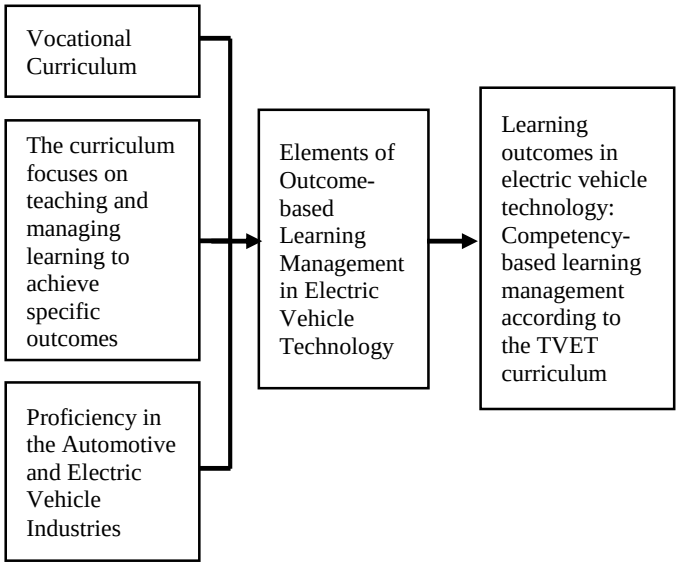

Fig. 1. The Conceptual Framework.

III. LITERATURE REVIEW

3.1 The Evolution of Curriculum and Teaching Methods in Technical and Vocational Education and Training (TVET)

In the realm of vocational education, the Vocational Education Committee establishes the "Vocational Education Curriculum." This curriculum combines global theoretical knowledge with Thai wisdom to develop students who possess both theoretical and practical skills. These skills equip students with the necessary abilities and knowledge to excel in professional positions or pursue independent careers (Office of the Vocational Education Commission, 2019).

Career and Technical Education (CTE) seeks to offer educational opportunities that empower students to investigate many professional domains and equip them for employment and self-sufficiency. The CTE curriculum prioritizes the cultivation of fundamental abilities, analytical reasoning, and personal qualities, alongside essential workplace skills and profession-specific expertise (Scott J. & Sarkees-W. M., 2008). CTE programs use classroom and laboratory settings to create simulated work experiences that closely resemble actual workplace circumstances. For example, a vocational program focused on automotive technology should have a fully equipped

laboratory. The goal is to improve the teaching and learning process in vocational education, with a focus on developing the necessary skills and competencies required by firms in the 21st-century digital technology-driven economy and fostering entrepreneurial skills among students. The intended outcome is for students to acquire proficiencies that align with the institution's curricular standards and desired competencies. Educational institutions have implemented updated curricula that align with the demands and requirements of the skills and labor markets. The findings can guide policymakers in formulating future education and labor market policies to develop curricula and learning programs that align with work requirements (Alekseeva L. et al., 2021).

3.2 Development of Learning Outcomes

Learning outcomes refer to the expected students' skills and knowledge that should be demonstrated through their learning activities. Highlighting learning outcomes necessitates an explicit definition of these outcomes, which serves as a roadmap for designing instructional activities. Concise declarations, known as learning outcomes, articulate the specific knowledge, understanding, and skills that learners should possess upon completion of a designated learning time. The outputs should accurately demonstrate the learner's proficiency in terms of comprehension, knowledge, skills, behaviors, and attitudes, embracing extensive application both within and beyond the educational institution (Kettunen J. et al., 2013).

The evaluation of learning outcomes assesses the observable behaviors that learners can demonstrate. These behaviors should be dynamic, attainable, measurable, and consistent at all levels, ranging from lesson plans to courses and the broader curriculum. Learning outcomes are critical in developing curricula that provide graduates with precise knowledge and skills. The design of the curriculum should prioritize the desired results for learners. The curriculum and course levels establish these outcomes, laying the groundwork for course design, teaching methods, materials, and assessment. Curriculum is defined as the arrangement of learning sequences to achieve specific and intended learning outcomes. On the other hand, curriculum development involves implementing planned modifications to improve educational results.

3.3 Teaching and Learning Management Plans in the Field of Electric Vehicle Technology

The learning management plan is the planning and design of activities that aim to provide learners with learning experiences and assessments that are consistent with the objectives of the curriculum. The learning management plan that has been used and developed is evidence of teaching and learning data and assessment that will be useful for organizing future teaching and learning activities (Lertchanadecha, T. 2023). Analysis of the learning management plan to determine the quality of learning in the education sector in line with the course curriculum (Wahyono, H., Cahyani, D., & Widiyanto, D., 2021). Guidelines for organizing learning in vocational education institutions that focus on learners, allowing learners to participate in activities and learning processes, and being able to create knowledge, skills, and desirable characteristics in organizing subjects in each semester, taking into account the subjects that must be studied in order, the ease and difficulty of the subjects, the continuity and interrelationship of the subjects, including subjects that can be integrated into learning management in the form of work, projects, and or pieces of work in each semester.

Teaching and Learning Management Plans in the Field of Electric Vehicle Technology are designed to respond to modern technology with meaning. Electric Vehicles (EVs) are vehicles powered by electric motors, which can operate solely on electricity or in conjunction with internal combustion engines. As global concerns about environmental issues and energy consumption grow, governments worldwide are adjusting policies to support electric vehicles. Intense electric vehicle R&D conducted by government agencies, academic institutions, and related industries is actively pursued. One of the distinct features of the recent EVs is the development of ground-up design. There is a clear difference between the performance of ground-up designed EVs and converted EVs, even though the latter adopt up-to-date technologies. Those differences are derived mainly from the differences in the weight and styles of the body and the system optimization (Chan, C. C., 1993). Therefore, the curriculum of the Electric Vehicle Technology program should consider the needs of the industry to prepare students to have the knowledge and skills necessary to work in the electric vehicle industry effectively and with skills that meet market demands.

The vocational education curriculum in the field of electric vehicle technology encompasses five essential abilities: 1) Electric vehicle maintenance. 2) Resolving issues and managing tasks related to electric vehicles. 3) Maintenance and repair of the electric charging and energy storage systems. 4) Maintaining and repairing the propulsion and power transmission systems. 5) Maintaining the control systems.

Pedagogical approaches in electric vehicle technology encompass a range of instructional techniques, which include hands-on training that adheres to industry benchmarks. This active learning methodology empowers students to develop expertise and drive innovation in the field. This study utilizes a hybrid technique for research and development, incorporating both qualitative and quantitative research approaches.

IV. METHOD

The research and development approach in this study employs a mixed methodology, integrating both qualitative and quantitative research methods. The research procedures are outlined as follows:

4.1 Participants

During the qualitative research phase, the project involves conducting interviews with department heads and teachers from educational institutions that provide courses on electric car technology. We will interview a total of 12 individuals. In addition, seven experts engage in focus group discussions through criteria selection (Miles and Huberman, 1994). The participants in the quantitative study phase consist of school administrators and teachers who are actively involved in teaching subjects connected to electric vehicles. This entails the participation of 20 educational establishments, comprising a collective total of 60 individuals.

4.2 Research Instruments

The research instruments utilized in this study consist of comprehensive interview forms applied to interview administrators and teachers. The interviews focus on subjects such as curriculum development, instructional management in electric car technology, teaching media and equipment, and the assessment of learning outcomes. The interview consists of a comprehensive examination that includes a structured set of questions focused on significant topics relevant to the research's content and aims (Longhurst, Robyn, 2009). Furthermore, the researchers utilize an opinion assessment form to evaluate the execution of the teaching management model in the domain of electric car technology. This examination employs a 5-point Likert scale (Likert R., 1932) for scoring. The criteria for interpreting average scores include the categories of Very High, High, Moderate, Low, and Very Low. Additionally, we collect excellent comments and ideas (Best, J.W., 1977).

4.3 Research Procedures

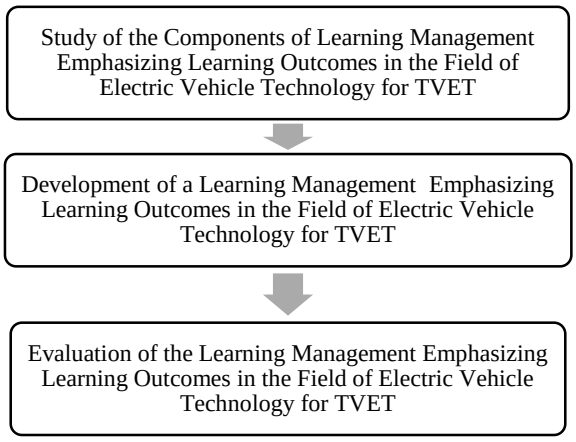

Fig. 2. Depicts the Research Steps

1) The Study of the Components of Learning Management Focusing on Learning Outcomes in the Electric Vehicle Technology Field for TVET

1.1 The research procedure includes scrutinizing and evaluating papers about competency-based curricula in educational institutions that provide courses associated with the Electric Vehicle Technology curriculum. The processes are as follows:

1.1.1 Establishing goals for the synthesis of materials for instruction centered on learning outcomes in the field of Electric Vehicle Technology for TVET

1.1.2 Conduct a comprehensive analysis of the competency-based curriculum papers from educational institutions that provide courses in Electric Vehicle Technology and document the research findings.

1.1.3 Collecting curriculum data from courses teaching Electric Vehicle Technology within the Vocational Education Office's curriculum and relevant bachelor's degree programs.

1.1.4 Analyzing and synthesizing the data gathered from these documents to conclude the analysis of information from the institutions.

1.1.5 Identifying specific components derived from data synthesis to draft the components of learning management that emphasize learning outcomes in the field of Electric Vehicle Technology for TVET

1.2 The study also entails assessing and scrutinizing educational institutions' capacity to provide electric vehicle technology courses, considering their preparedness in terms of staff, cooperation, and resources to improve teaching administration. The procedure involves completing the following steps:

1.2.1 Arranging meetings with educational institutions and businesses to evaluate the preparedness of enterprises to engage in collaborative efforts regarding teaching management.

1.2.2 Selecting branches that demonstrate readiness by conducting thorough interviews with department directors and instructors who offer electric vehicle technology courses. The readiness criteria include the necessary personnel, teamwork, and the availability of tools and equipment.

1.3 In-depth interviews are conducted with 12 department directors and teachers from six educational institutions that specialize in teaching electric vehicle technology. The interviews mainly focus on topics such as curriculum planning, teaching management in the electric vehicle technology field, instructional media and tools, and assessing learning outcomes. The process comprises the following steps:

1.3.1 Analyze different papers and textbooks to examine principles, concepts, and theories about the development of comprehensive interview rules. The researcher provided a concise overview of the concepts for formulating questions for comprehensive interviews with supervisors and lecturers in the domain of electric vehicle technology.

1.3.2. The researcher developed a thorough interview framework for instructors to address topics such as curriculum preparation, teaching management in electric vehicle technology, instructional media and resources, and learning outcomes evaluation.

1.3.3. Employed an interview style to collect data from department heads and teachers, and then synthesized and analyzed the gathered data.

1.4 Data were analyzed from individual interviews by utilizing the notes collected during those interviews. We will conduct a descriptive analysis by identifying the main themes and further categorizing them into sub-themes based on the given questions and content. Next, use content analysis to establish connections between them, focusing on the educational aspects and desired learning outcomes in the field of electric vehicle technology.

1.5 Summarize the components of instructional management that prioritize learning objectives in Electric Vehicle Technology for Technical and Vocational Education and Training (TVET). The researchers obtain these components by examining documents, combining data, and conducting interviews with department heads and teachers.

1.6 Evaluation of components by Nonparametric Inferential Analysis using the Chi-square test of One-Dimensional Classical Data.

2) Development of a teaching management format emphasizing learning outcomes in the field of Electric Vehicle Technology for TVET

2.1 This phase involves analyzing the curriculum of vocational certificate (Voc. Cert.) and higher vocational diploma (Dip.) courses in electric vehicle technology. The analysis is based on the data obtained from studying the components of teaching management that focus on learning outcomes. The curriculum analysis covers 10 academic semesters. The objective is to provide instructional materials that prioritize the achievement of learning outcomes in electric vehicle technology and establish topic areas according to the curricular outcomes.

2.2 The development of a teaching management format emphasizing learning outcomes in Electric Vehicle Technology for vocational education in Thailand is carried out through the following steps:

2.2.1 Synthesizing information gathered from meetings and knowledge exchanges to identify components of teaching management emphasizing learning outcomes in Electric Vehicle Technology.

2.2.2 Designing and creating a teaching management format that emphasizes learning outcomes in the Electric Vehicle Technology domain.

2.2.3 Creating tools for focus group discussions, such as setting up a schedule, preparing draft documents for the teaching management format that highlights learning outcomes in electric vehicle technology, and designing feedback forms for the proposed format.

2.2.4 Conducting assessments with the participation of seven experts, who examine the suitability of the developed format through focus group talks. We implement modifications to align the format with the instructional requirements in the electric vehicle technology field, considering factors such as utility, feasibility, propriety, and accuracy (Stufflebeam et al., 1989).

2.2.5 The analysis of the outcomes from the focus group discussion employs content analysis in four key areas: utility, feasibility, propriety, and accuracy. The researchers conducted this analysis to evaluate the application guidelines and provide recommendations for enhancing management practices. The emphasis in teaching will remain on achieving learning outcomes in the field of electric vehicle technology.

3) Assessment of the Instructional Management Focused on Learning Outcomes in the Field of Electric Vehicle Technology for TVET

3.1 This phase's data collection will focus on school administrators and teachers with expertise in the electric vehicle market or similar sectors. The study includes 20 educational institutions, with a combined total of 60 participants.

3.2 The assessment tools' development includes an evaluation form for instructional management that specifically targets learning outcomes in the field of electric vehicle technology for vocational education in Thailand. Additionally, there is a feedback form to gather opinions on the implementation of the instructional method in electric vehicle technology.

3.3 A panel of five specialists conducts a content validity evaluation. We then examine their input using the Index of Item Objective Congruence (IOC). We retain items with an IOC (Index of Clarity) value of 0.50 or above and refine the question contents to improve clarity and relevancy.

3.4 The proposed instructional management method for electric vehicle technology and the evaluation form to a total of 60 school administrators and teachers. We determined the response rate by receiving 55 feedback sets, resulting in a response rate of 91.66%.

3.5 The analysis of data is conducted using a 5-point Likert scale, which entails calculating the mean ($\bar{x}$) and standard deviation (S.D.). The criteria established by professionals are as outlined below:

A score of 5 signifies "Most Agreeable"
A score of 4 indicates "Agreeable"
A score of 3 represents "Neutral"
A score of 2 reflects "Disagreeable"
A score of 1 denotes "Least Agreeable"

3.6 The interpretation of the feedback relies on the calculation of average scores, which are categorized as follows:

4.50-5.00 indicates "Strongly Agree"
3.50-4.49 indicates "Agree"
2.50-3.49 indicates "Neutral"
1.50-2.49 indicates "Disagree"
1.00-1.49 indicates "Strongly Disagree"

3.7 To assess the effectiveness of the instructional management method in the field of electric vehicle technology for vocational education in Thailand, the feedback is evaluated based on specific criteria. Items with an average score of 3.51 or higher and a standard deviation of 1.00 or less are considered acceptable.

3.8 A comparison of opinions on the evaluation of teaching management models focusing on learning outcomes in the field of electric vehicle technology for vocational education curricula in Thailand, with the average criteria by Inferential Analysis with t-test one-sample test statistics.

V. RESULTS AND DISCUSSION

5.1 Findings from comprehensive interviews

An extensive series of interviews conducted with 12 branch heads and teachers specializing in electric vehicle technology from 6 educational institutions revealed a significant deficiency in the teaching and learning of this discipline. Tools and equipment for practice are not yet adequately prepared by instructors to effectively organize teaching and learning. To advance teaching and learning in the future, leaders and teachers in the field of electric vehicle technology share the same viewpoint: there is a necessity to establish comprehensive learning plans. The objective is to structure the instruction and learning process in the domain of electric vehicle technology. This includes selecting appropriate teaching materials and evaluating the achievement of learning objectives. The aim is to enhance the student's knowledge and skills.

TABLE I
SUMMARY OF THE OUTCOMES OF THE COMPREHENSIVE INTERVIEWS

Topic of interviews	Summary of the Information Results
Preparedness for Instruction and Acquisition of Knowledge	1. Teachers should acquire current expertise in electric vehicle repair. There should be an integration of teaching between the automotive and electrical branches. Regular professional development training in electric vehicle technologies is provided for teachers. 2. The tools and equipment utilized in the workplace should be contemporary and in alignment with established standards.
The organizing of teaching and learning activities	1. The curriculum should be designed and enhanced in alignment with institutions that manufacture and service electric vehicles. and modify the course material to ensure it is current. 2. The alignment between learning goals and training plans is not yet congruent with professional competence. Training plans should align with performance competencies as defined by professional standards. 3. Teaching and learning activities should prioritize operations based on the proficiency required in the electric vehicle technology industry.
The competency assessment based on learning outcomes	1. The assessment of learning outcomes and professional competence is currently lacking consistency with established criteria. There must be a standardized competency assessment guideline that is shared by both teachers in educational institutions and trainers in companies. 2. Students pursuing studies in electric vehicle technology should acquire accurate information and abilities by the professional norms of the sector and may effectively contribute to the electric car technology industry with high proficiency.

5.2 Results of the Study on Components of Instructional Management Focused on Learning Outcomes in the Field of Electric Vehicle Technology for TVET

By examining and assessing the preparedness of educational institutions, including their staff, cooperation, tools, and equipment, and by conducting meetings with both educational institutions and businesses to evaluate the possibility of collaborative instructional management, the elements of instructional management for electric vehicle technology have been determined. The following components are described in detail:

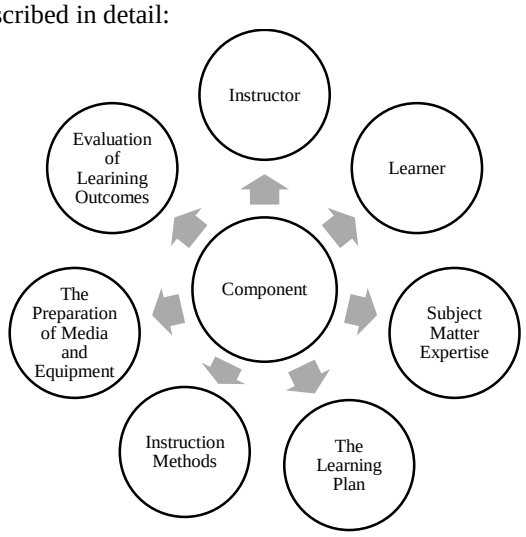

Fig. 3. Components of Instructional Management Focused on Learning Outcomes in the Field of Electric Vehicle Technology for TVET

Details of the Components

1. Instructor: The instructor plays a crucial role in the process of managing and facilitating learning. The instructor is accountable for choosing, adjusting, and customizing tactics and learning methodologies to ensure they are in line with the subject matter.

2. Learner: The learner plays a crucial part in the management of learning. Every learner has distinct attributes, such as their personality, intelligence, ability, and interests. Learners gain knowledge, develop skills, and foster positive attitudes towards their vocation.

3. Subject Matter Expertise: Instructors are required to structure the content and professional information in a way that aligns with the principles and concepts of electric vehicle technology.

4. The Learning Plan: The learning plan, created by the instructor, is an important element of teaching. It provides learners with step-by-step instructions for doing different exercises that help them study and comprehend the material. The instructor then evaluates the learners' performance based on their predetermined criteria.

5. Instruction in the Electric Vehicle Technology Sector: This aspect actively involves learners. For each learning unit, instructors utilize a blend of demonstrations and lectures. After learning, students then engage in communal and individual practice through the given projects. Knowledge exchange sessions are conducted after each class to establish a shared understanding.

6. The Preparation of Instructional Media and Equipment: The preparation of instructional media and equipment serves to enhance communication and promote efficient learning between the instructor and the learner. The preparedness of media, equipment, and other tools is crucial. Some instructional media may necessitate additional equipment or tools. The learning management team should choose captivating techniques that are suitable for the content and in line with the learning goals

7. Evaluation of Learning Outcomes: This component guarantees that learners can execute tasks in alignment with the desired results of the learning activities. The focus on these results, which are obtained through the educational process that follows set curricular standards, includes information, abilities, and desired characteristics. Diverse evaluation instruments are utilized, including examinations, exercises, individual practice sheets, group activity outputs, and behavioral observation assessments.

5.3 Evaluation results of teaching components focusing on learning outcomes in the field of electric vehicle technology for vocational education curricula in Thailand

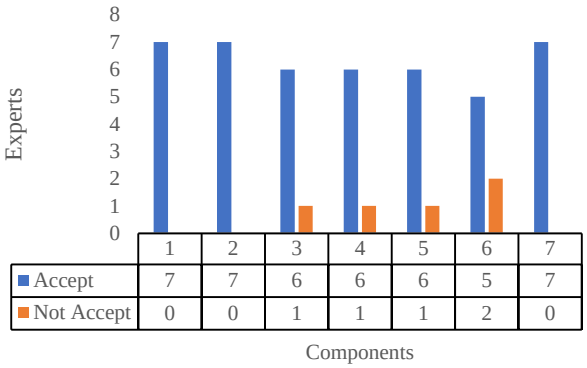

Fig. 4. Results of Components Evaluation.

From Fig. 4, experts evaluated the components of teaching and learning that emphasize learning outcomes in the field of electric vehicle technology for vocational education curricula in Thailand. It was found that overall, experts accepted all 7 components. The components of teachers, learners, and assessment of learning outcomes were all agreed upon by experts. As for the preparation of teaching media and equipment, 5 experts accepted it the least, and 2 did not.

TABLE II
RESULTS OF NONPARAMETRIC FACTOR ANALYSIS USING CHI-SQUARE TEST

Component	Observed (N)	Expected (N)	Residual
1.teacher	7	6.30	.7
2.student	7	6.30	.7
3.content	6	6.30	-.3
4.plan	6	6.30	-.3
5.learning	6	6.30	-.3
6.media	5	6.30	-1.3
7.evaluation	7	6.30	.7
		component	
Chi-Square		0.54	
df		6	
Asymp. Sig.		0.99	

$p \leq 0.01$

From Table II, the analysis results of the evaluation of the components of teaching management focusing on learning outcomes in the field of electric vehicle technology for vocational education curricula in Thailand found that the $\chi 2$ value was equal to 0.54 and the p-value was equal to 0.99, which is greater than 0.01. It can be concluded that all 7 components are related and are suitable for further development of the model.

5.4 Results of the Development of a Learning Management System Focusing on Learning Outcomes in the Electric Vehicle Technology Sector for TVET

The findings of a panel discussion with 7 specialists assessed the suitability of the instructional approach in the domain of electric vehicle technology, encompassing its practicality. The usefulness, appropriateness, and comprehensive accuracy of the information can be characterized as follows:

1. Feasibility Standards: The model exhibits the potential for practical application. Capable of replicating the researcher's methodology. The reason for this is that teaching and learning revolve around abilities that are derived from practical work in the field of electric vehicle technology. The curriculum has been designed according to professional standards.

2. Utility Standards: The structure is advantageous for teachers to utilize in their instruction and educational activities. Furthermore, this will significantly impact the students, enabling them to effectively execute their professional duties. It will be demonstrated that in the process of structuring teaching and learning each semester, there will be specific competencies established for each semester to ensure the assurance of quality. Students will acquire expertise in electric vehicle technology and develop proficiency in the field, ensuring they get comprehensive knowledge and skills.

3. Propriety Standards: The structure is specifically tailored to meet the needs of students and aligns with the abilities outlined in the occupational standards for electric vehicle technology.

4. Accuracy Standards: The format adheres to stringent criteria for ensuring the information and content it presents are precise and dependable. Verifying the precision of the information and content before its application in real-life teaching and learning scenarios. It yields learners of a caliber that aligns with professional benchmarks, requirements, and demands of the establishment.

The development of a teaching and learning management emphasizing outcomes-based learning in the field of electric vehicle technology for TVET yielded the following summarized model.

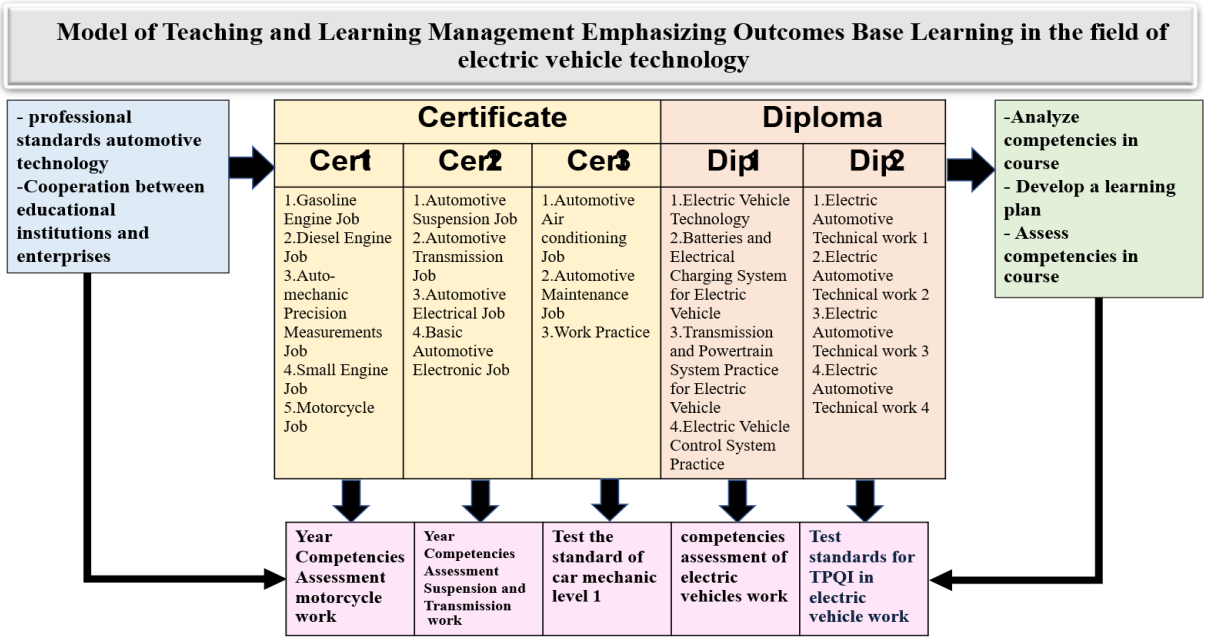

Fig. 5. Models of Outcome-Based Teaching and Learning in the Field of Electric Vehicle Technology for TVET

Development of a Teaching and Learning Management Emphasizing Outcomes-Based Learning in the Field of Electric Vehicle Technology for TVET. This model comprises three primary components with the following operational guidelines: Component 1: Preparedness for instruction and acquisition of knowledge.

The field of electric vehicle technology focuses on teaching and learning, with a strong emphasis on achieving specific learning goals. It is necessary to examine the professional standards of automotive technology and establish contact with the institution to collaborate in organizing collaborative instruction. Preparation for teaching in the field of electric vehicle technology involves various aspects that need to be considered:

1. Teachers can cultivate many kinds of learning strategies and methods. and arrange educational exercises that are suitable for the electric car technology course. Facilitating the preparation of media, tools, and teaching equipment to establish a connection between teachers and students, hence facilitating the process of learning. Media and equipment need to be prepared. Some teaching materials necessitate the use of additional equipment or tools. The learning manager must select approaches that are both engaging and suitable for the subject and aligned with educational goals.

Component 2: The organization of teaching and learning activities.

The process of organizing teaching and learning activities is crucial in education, with a focus on achieving desired learning outcomes. The field of electric vehicle technology encompasses various factors of teaching and learning activities, which include:

1. The teacher must structure the subject matter in the field of electric vehicle technology in a professional manner, ensuring that it aligns with the competencies required in electric car establishments.

2. When designing a 5-year curriculum for the Certificate of Vocational Education (CVE) and the Advanced Certificate of Vocational Education (ACVE), it is important to incorporate yearly competency evaluations and examinations that align with professional standards or labor skill standards. Table III has the specific information.

TABLE III
COURSE PLANNING

Grade	Course Organization	Annual Competency Assessment
Certificate of Technical Vocation Year 1	1. Gasoline Engine Work 2. Diesel Engine Work 3. Precision Measurement in Automotive 4. Small Engine Work 5. Motorcycle Work	Evaluation in Motorcycle Work.
Certificate of Technical Vocation Year 2	1. Chassis Work 2. Powertrain Work 3. Automotive Electrical Work 4. Automotive Electronics Work.	Evaluation in Drivetrain/Powertrain Work.
Certificate of Technical Vocation Year 3	1. Automotive Maintenance 2. Internship for at least 1 semester	Standardized Testing for Automotive Mechanic according to "Office of the Public Sector Development Commission" Level 1.
High Vocational Certificate Year 1	1. Electric Vehicle Control System Operations 2. Electric Vehicle Technology 3. Battery and Charging Systems	Assessment in Electric Vehicle Operations.

Grade	Course Organization	Annual Competency Assessment
High Vocational Certificate Year 2	1. Electric Vehicle Operations 1 2. Electric Vehicle Operations 2 3. Electric Vehicle Operations 3 4. Electric Vehicle Operations 4 Students are required to undergo professional training in enterprises for at least 2 semesters (10 months)	Assessment of TPQI Standards in Automotive Electrical Profession.

3. The learning management plan should be prepared by the teacher to facilitate the students' engagement in diverse activities. Measurement and assessment are implemented by the teacher once there is knowledge and understanding.

4. Teaching and learning in the domain of electric vehicle technology necessitates instructors structuring the learning process in a way that focuses on practical application and using teaching approaches that involve demonstrating concepts alongside traditional lectures. After completing each learning unit, the students should engage in practice activities. Engage in individual practice by completing prescribed worksheets.

5. Evaluating learning outcomes involves the utilization of several evaluation instruments, including examinations, exercises, and individual practice exercises. Activity model for generating work from group activities: behavioral observation assessment form.

Component 3: Continuous development.

Teachers must incorporate curriculum ideas that are in line with professional capabilities. This task entails examining the curriculum, devising educational strategies, and assessing subject-specific proficiencies to guarantee that students gain essential abilities in electrical automotive technology.

5.5 Evaluation Results of the Outcome-Based Teaching and Learning Approach in the Field of Electrical Automotive Technology for TVET.

TABLE IV
THE EVALUATION RESULTS OF OPINIONS ON THE OUTCOME-BASED TEACHING AND LEARNING APPROACH IN THE FIELD OF ELECTRICAL AUTOMOTIVE TECHNOLOGY

No.	Evaluation Item	$\bar{x}$	S.D.	Level of Opinion
1	The outcome-based teaching and learning approach in the field of electrical automotive technology is beneficial for education	4.49	0.69	Strongly Agree
2	The outcome-based teaching and learning approach in the field of electrical automotive technology helps students develop competencies aligned with their professions	4.38	0.89	Strongly Agree
3	The outcome-based teaching and learning approach in the field of electrical automotive technology is feasible for actual educational implementation.	4.40	0.71	Strongly Agree
4	The outcome-based teaching and learning approach in the field of electrical automotive technology is precise and accurate	4.29	0.74	Strongly Agree
5	The outcome-based teaching and learning approach in the field of electrical automotive technology is accurate and aligns with the curriculum's process and outcomes	4.35	0.73	Strongly Agree
Overview		**4.38**	**0.75**	**Strongly Agree**

An analysis of Table IV reveals that the overall opinion regarding the outcome-based teaching and learning approach in the field of electrical automotive technology garnered the highest level of agreement, boasting a mean score of 4.38 and a standard deviation (S.D.) of 0.75. Upon closer examination of each aspect, it was evident that there was a high level of agreement for all items.

The item with the highest average score was "The outcome-based teaching and learning approach in electrical automotive technology is beneficial for education," with a mean of 4.49 and an S.D. of 0.69. Following closely was "The outcome-based teaching and learning approach in electrical automotive technology is feasible for actual educational implementation," with a mean of 4.40 and an S.D. of 0.71. The item with the lowest score was "The outcome-based teaching and learning approach in the field of electrical automotive technology is precise and accurate," with a mean of 4.29 and an S.D. of 0.74.

5.6 Comparison of opinions on the evaluation of teaching management models focusing on learning outcomes in the field of electric vehicle technology for vocational education curricula in Thailand

TABLE V
THE RESULTS OF THE COMPARISON OF OPINIONS ON THE EVALUATION OF THE TEACHING MODEL FOCUSING ON LEARNING OUTCOME IN THE FIELD OF ELECTRIC VEHICLE TECHNOLOGY FOR VOCATIONAL EDUCATION CURRICULUM IN THAILAND

No.	Evaluation Item	N	$\bar{x}$	S.D.	t	P
1	The outcome-based teaching and learning approach in the field of electrical automotive technology is beneficial for education.	55	4.49	0.69	66.01	0.00
2	The outcome-based teaching and learning approach in the field of electrical automotive technology helps students develop competencies aligned with their professions.	55	4.38	0.89	66.27	0.00
3	The outcome-based teaching and learning approach in the field of electrical automotive technology is feasible for actual educational implementation.	55	4.40	0.71	66.00	0.00

No.	Evaluation Item	N	$\bar{x}$	S.D.	t	P
4	The outcome-based teaching and learning approach in the field of electrical automotive technology is precise and accurate.	55	4.29	0.74	66.42	0.00
5	The outcome-based teaching and learning approach in the field of electrical automotive technology is accurate and aligns with the curriculum's process and outcomes.	55	4.35	0.73	67.15	0.00

$p \leq 0.05$

From TABLE V, the results of the comparison of the evaluation of opinions on the teaching model that emphasizes learning outcomes in the field of electric vehicle technology for vocational education curricula in Thailand, the evaluation items have an average value higher than the specified criterion of 3.51 for all items, with statistical significance at the 0.05 level.

Conduct comprehensive interviews with department directors and professors who specialize in teaching electric car technologies. The study revealed that there is a need to enhance the teaching and learning practices in the field of electric vehicle technology. Afri Yudantoko. et. al. (2024) suggest encouraging the professional development of instructors in this field. Vocational automotive instructors must cultivate and modify their skills. The process of learning to cope with and stay updated on automotive technology should be conducted continuously and sustainably (Sarkaya Erdem et. al., 2019). The teacher plays a crucial role in this process through their knowledge, course design, content presentation, and organization of the learning environment, all of which contribute to effective training. The agency received assistance and equipment from Anindo et. al. (2016). There is an insufficient number of teachers. Contemporary training equipment is insufficient. Industry affiliation and support are subject to a variety of constraints. To attain the desired outcomes by enhancing student abilities, the government should bolster TVET colleges by furnishing students with state-of-the-art equipment for practical training. Furthermore, educational institutions must form alliances with enterprises to collaborate on shared professional training initiatives (Abdullah, N. et. al., 2015). Challenges arise while implementing the organization of teaching and learning in vocational education courses, as well as when working together and offering career experiences for students. Ensure a consistent alignment with the employer's requirements and preferences. The involvement of multiple stakeholders, such as school administrators, teachers, parents, government agencies, the private sector, and communities, is essential for the implementation of diverse initiatives. The plan was executed with success.

The components of outcome-based education in the field of electric automotive technology for vocational curricula consist of instructors, learners, vocational content, learning plans, teaching in electric automotive technology, preparation of instructional media and tools, and assessment of learning outcomes (Zheng W. et.al., 2023). This comprehensive approach enhances teaching efficiency and quality. Effective lesson planning and use of efficient teaching methods, along with the assessment of learning outcomes, contribute to improved teaching quality (Supaksorn F. & Kobsook K, 2016). The components and details of the teaching model were derived from the synthesis of data from various sources, including interviews with teachers, and administrators, and meetings with experts. The data highlights the importance of vocational content, learning plans, and the assessment of learning outcomes, all of which are essential for high-quality learning processes. This aligns with the work of Nilobon T. et.al., (2018), emphasizing the need for structured learning processes with content and activities addressing literacy issues, systematic plans for addressing reading and writing problems, and consistent plan execution (Shukla, T. et.al., 2020). By ensuring the quality of instruction and employing effective classroom management strategies, student learning outcomes can be enhanced. Student characteristics, such as motivation and participation in discussions and group activities, contribute to their social recognition and status. Simple user interface designs, adequate resources, technological support, and dedication are all essential for improving learning effectiveness.

The group chat will discuss whether the teaching and learning approach in the field of electric car technology is suitable. If something is possible, useful, appropriate, accurate, and all-encompassing, then the way it is taught and learned should include competency-based lessons based on real-life uses of electric vehicle technology (Kurilovas, E., Kurilova, J., and Andruskevic, T., 2016). Personal learning kits should consist of educational materials and activities that facilitate the process of acquiring knowledge and skills. The content includes educational resources, instructional tasks, and the optimal educational setting tailored to individual students based on their unique learning preferences (Nguyen, N. D., 2024). Students can self-assess and receive evaluations from others based on the job appropriateness level. Hence, we formulate a strategy for enhancing our abilities and attributes during our educational journey to cultivate higher levels of proficiency in the workplace. Students' adherence to the competencies outlined in occupational standards for electric vehicle technology has a direct impact on their ability to effectively carry out their professional responsibilities (Thilakaratne, R. et. al., 2006). In professional education environments, competency-based assessment should prioritize learning and teaching that go beyond just performance. Establishing evaluation criteria through suitable comparisons emphasizes the importance of both emotional capabilities and work performance. Professional standards align with the curriculum (Louden, W., 2000). In Australia, professional norms have advanced. Advocates assert that standards ought to be succinct, easily understandable, tailored to specific needs, relevant to the situation, and centered on the process of education and acquiring knowledge. The standards should align with a

thorough assessment and fulfill the requirements of the organization (Nurhadi, D. et. al., 2017). Vocational education teachers must possess expertise and proficiency to effectively impart knowledge at any given moment. To align with the technological advancements in the industrial sector.

The instructional management model emphasizing learning outcomes in the field of electric automotive technology for TVET comprises three components: Data Preparation, Lesson Planning, and Continuous Development. This approach to teaching management is based on systematic practices, offering comprehensive and curriculum-aligned instructional management. This planning encompasses the entire curriculum and emphasizes student learning outcomes. This aligns with the work of Khwanchai K. et. al. (2018), where the teaching model they developed integrates theories and ideas from learning management studies into a cohesive instructional framework aimed at enhancing students' learning skills (Khabiri, M.M. et. al., 2019). The proactive teaching method in skill instruction can enhance effective teaching and improve student satisfaction. According to Budhtranon, W. et. al. (2021), this instructional paradigm leads to student outcomes encompassing knowledge, skills, and essential attributes for developing socially responsible business projects, risk management, and creativity. The development of an innovative project teaching model is also influenced by the sufficiency economy philosophy, focusing on balancing prosperity, society, environment, and culture with risk management.

Evaluating the instructional management model focused on learning outcomes in the electric automotive technology sector for vocational education courses reveals a high level of overall agreement. This is because the learning outcomes-focused instructional management model proves beneficial for teaching and is feasibly implemented, resulting in a high confidence level among the evaluators. This is in line with Tossaporn D. et.al. (2021), where the quality assessment of a blended learning format combined with proactive learning methods aimed to enhance students' information technology and communication competencies. It was found that in terms of utility, feasibility, appropriateness, and correctness, the quality was rated at the highest level. Akkarat P.& Rinradee P. (2021), the evaluation in four dimensions, namely utility, appropriateness, correctness, and feasibility of application, was overall ranked at the highest level (Patcharin C. et. al., 2021). Assessed learning formats using research as a basis for instructional management in vocational subjects under the Office of the Vocational Education Committee. Overall, it was deemed highly appropriate, with utility being the highest-rated dimension. As noted by Pimthong A. et. al. (2022), the evaluation of the format's appropriateness, based on the opinions of school administrators, experts, and organization executives, indicates that both the appropriateness and feasibility were rated at the highest levels. This reflects a clear, systematic model of a bimodal education built in line with the quality management cycle of planning, execution, inspection, and suitable actions.

VI. RECOMMENDATIONS

This is advisable to conduct an in-depth study to examine the outcomes resulting from the implementation of an instructional management model that emphasizes learning results in the electric automotive technology sector within TVET. Educational institutions offering programs in electric automotive technology should consider adopting this model and regularly evaluate the learning outcomes. This practice will help ensure that students consistently acquire competencies that align with the industry's requirements. Emphasis should be placed on the development of assessment tools tailored to learners, with a specific focus on guaranteeing the attainment of competencies following professional standards. This strategic approach will further enhance the quality of instructional management. Future research endeavors should explore and establish appropriate learning designs for instructional delivery in the electric automotive technology sector. These designs can serve as valuable guidelines or prototypes for structuring effective learning experiences in industrial technician courses and other related fields within vocational education institutions. There is a need for further investigation into the relationship between outcome-focused instructional management and students' learning achievements. A comprehensive understanding of this relationship will provide valuable insights to refine the instructional management model and enhance its effectiveness in facilitating positive learning outcomes. Additional research efforts should aim to identify and analyze the variables that influence outcome-focused instructional management. These identified variables can then be incorporated into an instructional management model that authentically aligns with students' learning outcomes.

CONCLUSION

The components of the teaching and learning process in electrical automotive technology include instructors, learners, professional subject content, learning plans, teaching methods specific to the electrical automotive domain, preparation of teaching materials and tools, and evaluation of learning outcomes. The development of the outcome-based teaching and learning approach in electrical automotive technology for the TVET comprises three main segments: The first segment, the readiness for teaching and learning, requires the study of professional standards in automotive technology and coordination with industries for collaborative teaching efforts. Additionally, preparations must be made in terms of staff readiness, collaborative efforts, and tools and equipment. The second segment involves organizing teaching and learning activities, curriculum planning, and laying out a 5-year plan for both the vocational certificate and advanced vocational certificate levels, with annual competency assessments and evaluations based on professional or labor standards. The third segment pertains to continuous development, where instructors are responsible for developing individual subject curricula through curriculum analysis, crafting learning plans, and assessing subject-specific competencies to ensure students achieve the desired skills in the electrical automotive domain. The evaluation of the outcome-based teaching and learning approach in the electrical automotive domain for TVET showed a predominant positive agreement overall.

As the electric automotive industry continues its rapid growth and evolution, the importance of implementing an effective and comprehensive educational approach cannot be

overstated. This research underscores the critical significance of adopting an instructional management model that places a strong emphasis on outcome-based learning results, particularly tailored to meet the needs of vocational courses in electric automotive technology in Thailand.

By refining and developing assessment tools that closely align with professional standards, educational institutions can play a pivotal role in ensuring that students consistently acquire genuine competence in this field. The research recommendations provided emphasize the ongoing commitment to improvement, not only in content delivery but also in the evaluation of students' achievements. Embracing these strategies will not only equip the future workforce with the essential skills and knowledge required to make meaningful contributions to the electric automotive industry but also extend their impact to related sectors. This holistic approach to vocational education promises to yield well-prepared graduates who are poised to excel in a dynamic and evolving professional landscape.

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