

Research Article

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An Outcome-Based Education Module Incorporated into a Blended Learning Approach to Enhance Students' Skill in Modern Automobile Parts Manufacturing Industry in Work-Integrated Learning

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Abstract

Background/purpose. The Automobile Parts Manufacturing Industry (APMI) is currently facing rapid changes due to continuous technological innovations. These shifts are reshaping the skills required for future workforce participation in the sector. Consequently, it is essential to prepare students with future-oriented competencies that align with the demands of industry. This study aims to identify the key future skills needed in the APMI and to develop an Outcome-Based Education Module (OBEM) that incorporates blended learning methodologies. The research further investigates the effectiveness of the OBEM in enhancing students' future skills.

Materials/methods. This research was conducted in three phases as follows: 1) an investigation into the expected future skills required in the APMI; 2) the development of an OBEM; and 3) an evaluation of the effectiveness of the OBEM in enhancing future skills.

Results. The research findings revealed that future skills required in the APMI can be categorized into two main groups: Professional Skills and Soft Skills. Based on these identified skill demands, five modules were developed within the OBEM, specifically tailored for the APMI context. Students who participated in the learning process through the OBEM, which integrated OBEM with blended learning approaches, demonstrated statistically significant improvements in future skills required for the APMI.

Conclusion. The research findings can be applied to the design of undergraduate courses or developed into training programs aimed at preparing students prior to their participation in work-integrated learning. This approach enhances students' competencies by equipping them with future skills that closely align with the needs of the APMI.

1. Introduction

The Automobile Parts Manufacturing Industry (APMI) is currently undergoing rapid transformation, largely driven by continuous innovation in technology. Enhancing production processes to achieve maximum efficiency, reduce operational costs, and increase flexibility to adapt to changing market demands has become critically important. Thailand serves as one of the world's key automotive manufacturing hubs, producing approximately 1.9 million vehicles annually—the highest in ASEAN and ranking tenth globally (ASEAN Automotive Federation, 2022). Among the country's top exports are automotive components and parts, which play a vital role in the automotive supply chain. Emerging technological trends, including energy storage, production automation systems, artificial intelligence, and digitalization, are prompting fundamental shifts across the automotive sector (Lempp & Siegfried, 2022). Automotive parts manufacturers are now required to prepare for the transition in production, particularly for shared parts such as body panels, brakes, interiors, seats, and decorative equipment. In response, manufacturers are increasingly integrating advanced technologies, including robotics and automation systems, into production processes to enhance productivity (Casper & Sundin, 2021). Additionally, the rise of electric vehicles (EVs) necessitates the development of new components and the adaptation of existing manufacturing systems.

The trend of rapid technological transformation in the automotive parts manufacturing sector, particularly innovations such as electric vehicles (EVs) and automation, has resulted in a significant employability gap among undergraduate graduates, as curricula and experiences aligned with the industry's real needs have yet to keep up. (Rady et al., 2023) (Saleet et al., 2023) Given these shifts, it is essential to equip students with future-oriented skills before they enter work-integrated learning environments in automotive parts manufacturing enterprises. Undergraduate students in industrial technology programs must be prepared to apply modern technologies and adapt to evolving production environments. Implementing an Outcome-Based Education Module (OBEM) is a strategic approach to ensuring students acquire the relevant competencies aligned with industry demands.

Accordingly, this research aims to identify the future skills required by the APMI and to develop an OBEM integrated with blended learning strategies. The study also evaluates the effectiveness of the OBEM in enhancing students' future skills. The research findings can be used to inform the design of undergraduate curricula or to develop training programs that prepare students for work-integrated learning, ultimately helping them acquire skills that meet the current and emerging needs of the automotive parts manufacturing sector and respond effectively to industry changes.

2. Literature Review

2.1. Outcome-Based Education and Blended Learning

Outcome-Based Education (OBE) is an educational approach that focuses on aligning curriculum design and teaching methods with the intended learning outcomes. This approach emphasizes equipping students with the essential knowledge and skills required for future employment (Biggs, 2022). The focus on clear learning outcomes necessitates instructional strategies that target the development of explicit student competencies (Popham, 2021). Such an approach enhances students' ability to acquire job-relevant skills across various disciplines (Tucker et al., 2023).

To adequately prepare undergraduate students in industrial technology for work-integrated learning environments, the development and implementation of Outcome-Based Education Modules (OBEM) is crucial. OBEM equips students with future-ready skills that align with industry demands, including data analysis, problem-solving, and teamwork—key competencies in the era of Industry 4.0 (Hamidi et al., 2024; Lkhagvaa et al., 2024).

The integration of blended learning into OBEM—combining face-to-face instruction with digital or online learning—has been shown to significantly enhance academic achievement and support the attainment of intended learning outcomes (Li & Wang, 2022; Tabassum et al., 2024). Blended learning promotes active learning through diverse instructional activities such as online exercises, videos, and e-learning modules, complemented by classroom-based interactions. This dual-mode approach enhances engagement, promotes deeper understanding, and facilitates personalized learning experiences. Students can progress at their own pace, revisit unclear content, or skip what they already understand, thereby enabling more effective mastery of content aligned with their individual learning capacities. Furthermore, formative assessment is enhanced using online quizzes and real-time feedback, encouraging continuous learning and improvement (Vodovozov et al., 2022; Ghannam & Chan, 2023).

Blended learning not only strengthens academic knowledge but also helps students develop essential skills for today's dynamic work environments, including technological literacy, collaboration, analytical thinking, and other critical professional competencies (Sangrà, 2019; Tong et al., 2022). Therefore, the application of OBEM integrated with blended learning contributes significantly to preparing students with the knowledge and practical skills required in the workplace. It also enhances the effectiveness of professional training and better addresses labor market demands.

2.2. Work-Integrated Learning

Work-integrated Learning (WIL) serves as a strategic mechanism to align student competencies with industrial requirements. It facilitates collaboration between educational institutions and enterprises, enabling students to balance classroom-based instruction with real-world experience in the workplace. WIL emphasizes producing graduates with strong academic foundations and practical vocational skills. Through WIL, students develop a conceptual understanding, apply theoretical knowledge in professional settings, and enhance higher-order thinking skills, such as critical analysis, problem-solving, and decision-making. Additionally, WIL fosters interpersonal skills, including teamwork, communication, and conflict resolution (Fergusson et al., 2021; Lasrado et al., 2023; Jackson et al., 2023).

Collaboration between academic institutions and industries fosters learning communities that contribute to innovative knowledge development, which is essential for solving complex industrial challenges. This is particularly relevant in the APMI, which must rapidly adapt to technological changes and market fluctuations (Casper, 2021). For instance, Jebba et al. (2024) found that training automotive engineering students using On-Board Diagnostics II (OBD II) tools within WIL environments significantly enhanced diagnostic skills and work readiness. Similarly, Prohimi et al. (2023) highlighted the effectiveness of experiential learning and reflective practice in developing both technical and soft skills necessary for navigating Industry 4.0.

Furthermore, Ruwaida and Sudira (2024) analyzed the impact of school-industry collaboration on enhancing students' automotive skills and competitiveness in the labor market. Their findings emphasize that effective partnerships between schools and industries significantly improve students' employability.

Although relevant research has emphasized the importance of outcome-based education, blended learning, and work-integrated learning in student skill development, there is a lack of research that systematically integrates all three approaches, particularly in the context of the automotive parts manufacturing industry (APMI), which is undergoing rapid technological change as part of Industry 4.0.

3. Methodology

3.1. Research Objectives

This study was conducted with the aim of enhancing the alignment between educational outcomes and the skill demands of the APMI under the influence of rapid technological changes. The specific research objectives are as follows:

1. To identify the future skill requirements relevant to the APMI in the context of Industry 4.0 and digital transformation.
2. To develop an Outcome-Based Education Module (OBEM) integrated with a blended learning approach that addresses the identified skill requirements and supports the preparation of undergraduate students in industrial technology programs.
3. To examine the effectiveness of the developed OBEM and blended learning approach in enhancing future skills among students, specifically those aligned with the needs of the automotive parts manufacturing sector.

3.2. Conceptual Framework

This research is grounded in four key conceptual foundations. These are described as follows:

1. Outcome-Based Education (OBE): Outcome-Based Education focuses on learning driven by clearly defined learning outcomes. Learners are expected to demonstrate the competencies acquired through the learning process. These outcomes serve as the foundation for designing instructional activities, assessment methods, and overall teaching and learning management.
2. Blended Learning: Blended Learning is an instructional approach that combines face-to-face classroom learning with online learning. It enhances flexibility and accessibility to diverse learning resources, supporting both 'deep learning' and 'practical application'.
3. Work-Integrated Learning (WIL): Work-Integrated Learning is an educational approach that integrates real workplace experiences into the learning process. It allows students to engage in hands-on practice within actual industrial contexts, promoting experiential learning and the development of professional skills.
4. Modern Automobile Parts Manufacturing Skills: The research on Modern Automobile Parts Manufacturing Skills focuses on both professional and soft skills required in the evolving automotive industry. Professional skills include the application of automation systems in industrial settings, programming and integrating human-machine communication interfaces, programming motion paths for industrial welding robots, and utilizing software to simulate metal forming behavior, among other skills. Soft skills essential for modern manufacturing include problem-solving, collaboration, communication, and creativity.

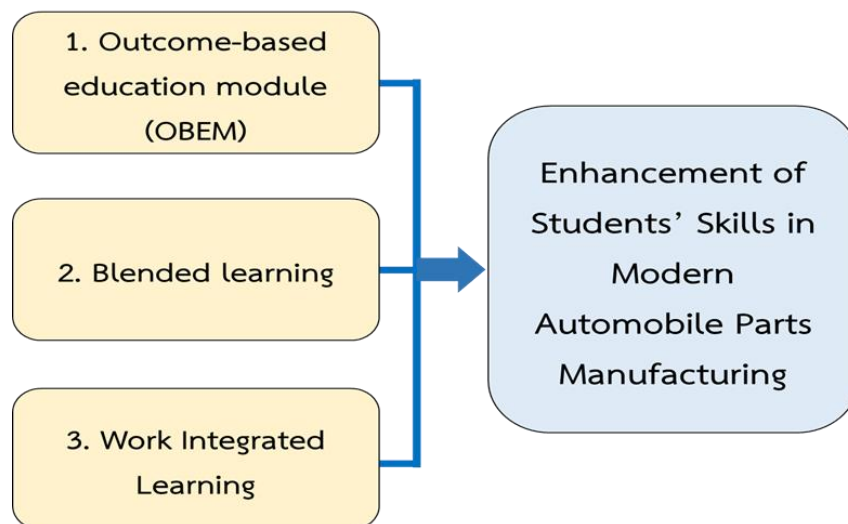


Figure 1. Conceptual Framework

Based on the four key conceptual frameworks underlying this study, a research framework was developed as illustrated in Figure 1. The independent variable consists of the outcome-based education learning module, which is designed using a blended learning approach. The dependent variable is the students' skills in modern automobile parts manufacturing.

3.3. Research Design

This study employed a mixed-methods research methodology, which combines quantitative and qualitative research to produce comprehensive and in-depth results. The researcher organized the research into three phases, which are listed below:

Phase 1: Investigation of Future Skill Requirements for the Automobile Parts Manufacturing Industry

The first phase involved collecting data on the anticipated future skills required for the APMI. These skills are necessary for students engaging in work-integrated learning within the industry to effectively adapt to future technological changes. Data were collected through in-depth interviews with key stakeholders and then analyzed to identify the skill requirements. The detailed research procedures are described below:

1. Key Informant Interview Group

Purposive sampling was used to identify the 40 participants who gave information during the interviews. It was made up of employees from 20 automotive parts manufacturing companies, specifically Tier 1 and Tier 2 manufacturers (two people per company), comprising department-level executives and above, as well as engineers with at least five years of experience

2. Research Instruments

Semi-structured interview guides were developed for conducting in-depth interviews. The interview questions were derived from an extensive review of related theories, concepts, and reports, including the Future of Education and Skills: Education 2030 by the Organization for Economic Co-operation and Development (OECD), as well as relevant academic literature. The interview guide consisted of two parts: Part 1 collected personal information of the interviewees, and Part 2 contained the interview questions structured into four sections: 1) Introduction, 2) Interviewer information, 3) Interviewee information, and 4) Main questions.

Five experts evaluated the interview guide for content validity, alignment with research objectives, language appropriateness, and clarity. The Index of Item-Objective Congruence (IOC) was calculated for each question, with all items scoring at least 0.67. The overall IOC for the instrument was 0.95, indicating excellent content validity.

3. Data Collection Procedure

Data was collected by the principal researcher and research assistants. Two participants from each company were interviewed. The researcher conducted the interviews, while the research assistant recorded the responses. Data collection took place onsite at 20 automobile parts manufacturing companies, with each company's interviews completed within one day.

4. Data Analysis

Data from Part 1 (demographic information) were analyzed using frequency and percentage statistics. Data from Part 2 (interview responses) were analyzed qualitatively through a combination of content analysis and inductive analysis. The identified skills were categorized into Professional Skills and Soft Skills. Frequencies and percentages were calculated, and the levels of skill expectation were interpreted using the following five-point scale:

85.00 – 100.00: Highest expectation

75.00 – 84.99: High expectation

65.00 – 74.99: Moderate expectation

55.00 – 64.99: Low expectation

0.0– 54.99: Very low expectation

Phase 2: Development of the Outcome-Based Education Module (OBEM) Integrated with Blended Learning Approach

The researchers employed the Constructive Alignment framework (Biggs & Tang, 2011), the five-step curriculum development model by Saylor, Alexander, and Lewis (1981), and the concept of blended learning to develop an Outcome-Based Education Module (OBEM) integrated with a blended learning approach. This module aimed to enhance modern automobile parts manufacturing skills among students prior to their participation in work-integrated learning at industrial workplaces. The research procedures are as follows:

1. Skills expected by industry, including both Professional Skills and Soft Skills, were derived from Phase 1. Only those skills with a high level of expectation (scores of 75.00 – 84.99 or above) were selected to formulate learning outcomes. Bloom's Taxonomy was applied, utilizing appropriate levels of learning and action verbs, to precisely articulate these learning outcomes.

2. Design of the OBEM: The Constructive Alignment concept was applied, encompassing three key components: 1) Module Learning Outcomes, 2) Learning Activities, and 3) Assessment. These served as the foundational framework for developing the OBEM, as illustrated in Figure 1. The OBEM was developed following the five-step curriculum design process proposed by Saylor, Alexander, and Lewis, comprising: 1) Curriculum Goals and Objectives (Learning Outcomes) 2) Selection of Content 3) Organization of Content 4) Selection and Organization of Learning Experiences and 5) Curriculum Evaluation. The OBEM's instructional approach was based on blended learning, with a content ratio of 30% theoretical instruction delivered via e-learning lessons and 70% face-to-face teaching and practical training (Allen & Seaman, 2013; Graham, 2006).

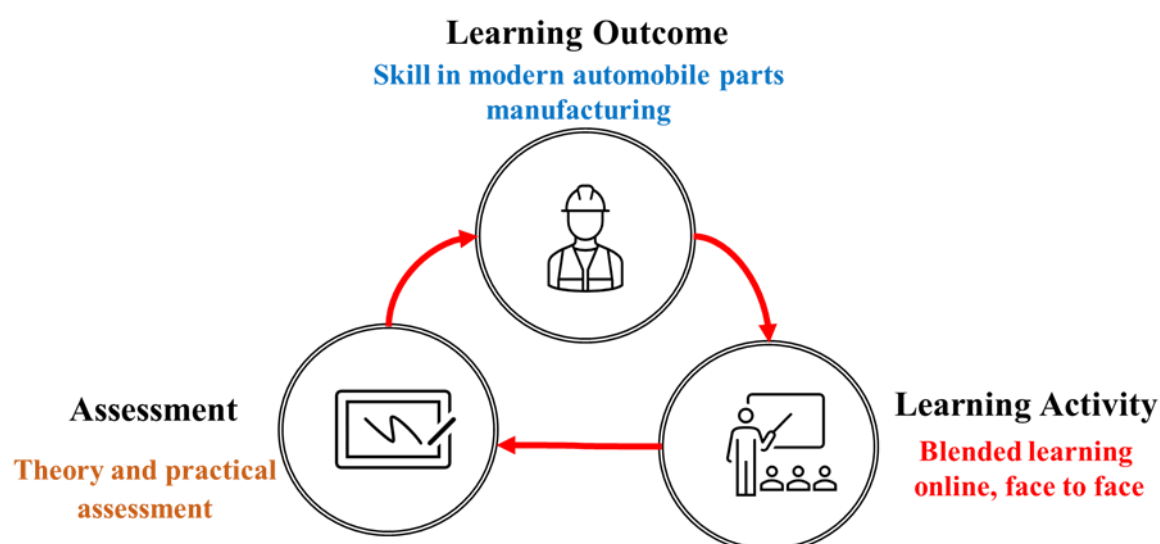


Figure 2. Concept of Constructive alignment

3. The quality of the OBEM was evaluated by a panel of five experts specializing in curriculum and content design as well as education and teaching. Among these experts, three hold doctoral degrees in Education, and two hold doctoral degrees in Engineering. All experts have a minimum of five years of relevant professional experience. They were selected using purposive sampling. The evaluation employed a five-point rating scale, with the criteria set that the mean appropriateness score must be at least 3.50, and the standard deviation should not exceed 1.0. If these criteria were met, the OBEM framework was considered appropriate and suitable for implementation.

4. Two types of assessment instruments were developed including, the OBEM achievement test, consisting of 55 multiple-choice questions with four options each and five practical skills assessment tools. The quality of these assessment instruments was reviewed by five experts in curriculum and content design as well as measurement and evaluation, all holding doctoral degrees in Education and having at least five years of professional experience. These experts were also selected by purposive sampling. They evaluated the consistency between the test items and the OBEM learning outcomes using the Index of Consistency (IOC). Additionally, the assessment tools were pilot-tested with 20 students enrolled in the Bachelor of Technology program in Industrial Technology, who were not part of the study sample. The detailed results of the evaluation are presented in Tables 1 and 2.

Table 1. Evaluation Results of the Quality of the OBEM Achievement Test: "Automobile Parts Manufacturing for the Future Automotive Industry"

Module Title	Index of Item-Objective Congruence (IOC)	Discrimination Index	Reliability Coefficient	Number of Test Items
1. Quality Control and Standards for the Automotive Industry	0.60 – 1.00	0.35 - 0.80	0.89	12
2. Intelligent Manufacturing Systems for Automotive Parts Production	0.70 – 1.00	0.20 - 0.77	0.84	12
3. Engineering Materials and Metal Forming for	0.80 – 1.00	0.30 - 0.70	0.87	10

Automotive Parts Manufacturing				
4. Welding Technology and Quality Inspection for Automotive Parts	0.60 – 1.00	0.36 - 0.74	0.83	11
5. Battery Technology for Electric Vehicles	0.60 – 1.00	0.35 - 0.80	0.89	12
Total Number of Test Items				55

Table 2. Quality Evaluation Results of the OBEM Practical Skills Assessment: “Automobile Parts Manufacturing for the Future Automotive Industry”

Module Title	Practical Skills Assessment	Index of Item-Objective Congruence (IOC)	Reliability Coefficient
1. Quality Control and Standards for the Automotive Industry	1. Evaluation Form for Problem-Solving Presentation Using Quality Tools	0.60 – 1.00	0.91
2. Intelligent Manufacturing System for Automotive Parts Production	2. Evaluation Form for Control of Commands Using Programmable Logic Controller (PLC) and Internet of Things (IoT) Connectivity	0.80 – 1.00	0.93
3. Engineering Materials and Metal Forming for Automotive Parts Manufacturing	3. Evaluation Form for Using Software to Simulate Metal Forming Behavior	0.70 – 1.00	0.88
4. Welding Technology and Quality Inspection for Automotive Parts	4. Evaluation Form for Robotic Welding of Automotive Parts and Weld Quality Inspection	0.70 – 1.00	0.92
5. Battery Technology for Electric Vehicles	5. Practical Evaluation Form for Battery Pack Preparation, Assembly, and Characteristic Testing	0.60 – 1.00	0.86

5. The screening of the OBEM was conducted by a panel of seven experts who reviewed, approved, and provided recommendations regarding the OBEM as follows: 1) Four personnel from the APMI, including managers at the department head level or higher, each with at least five years of work experience. 2) Three academic administrators responsible for academic affairs, including an associate dean, a department head, and a program chair. The selection was made using purposive sampling.

6. The effectiveness of the OBEM, combined with blended learning methods, was evaluated with 20 non-sample students enrolled in the Bachelor of Technology program, Industrial Technology major. The criteria used was the correlation between process and achievement (E1/E2), with a set standard of no less than 75%/75%. Scores were calculated from skill assessments conducted during OBEM learning and from post-OBEM skill evaluation assessments.

Phase 3: Study the Effectiveness of the Outcome-Based Education Module (OBEM) Combined with Blended Learning Methods on Future Skills for the APMI

The effectiveness study of the OBEM combined with blended learning methods on “Automotive Parts Manufacturing for the Future Automotive Industry” employed a posttest-only design with nonequivalent groups. The details are as follows:

1. The sample consisted of 40 third-year undergraduate students from the Bachelor of Technology program, Industrial Technology major, Faculty of Industrial Education and Technology, King Mongkut’s University of Technology Thonburi. Participants were selected by cluster random sampling and divided into two groups of 20 students each:

Group 1: Experimental group learning through the OBEM combined with blended learning methods (20 students)

Group 2: Control group learning through conventional instruction (20 students)

2. Research Instruments

The research instruments consisted of:

1. Outcome-Based Education Module titled “Automotive Parts Manufacturing for the Future Automotive Industry” combined with blended learning methods.

2. Achievement test consisting of 55 multiple-choice questions with four options each.

3. Practical skill evaluation forms, totaling 5 different assessments.

3. Data Collection

The OBEM combined with blended learning methods was implemented as follows:

Group 1: Learned using the OBEM “Automotive Parts Manufacturing for the Future Automotive Industry” combined with blended learning methods. The course comprised 5 modules with a total of 90 h of instruction over 15 days, followed by a 4.5-hour evaluation session (1 hour of theory and 3.5 h of practical assessment).

Group 2: Learned using conventional instruction with the OBEM “Automotive Parts Manufacturing for the Future Automotive Industry.” The course duration was 90 h (15 days), followed by a 4.5-hour evaluation session (1 hour theory and 3.5 h practical).

4. Data Analysis

The results of the skill evaluation for modern automotive parts manufacturing were converted to percentages and interpreted according to the following criteria. The expected skill competency threshold was set at a good level (75.00%), indicating that students achieved the expected learning outcomes. The interpretation scale is as follows:

87.50 – 100.00: Excellent skill level

75.00 – 87.49: Good skill level

62.50 – 74.99: Moderate skill level

50.00 – 62.49: Low skill level

00.00 – 49.99: Very low skill level

Next, a comparison of the mean scores between the two independent sample groups was conducted. Since both groups had equal sample sizes, the researchers used an independent t-test with pooled variance to analyze the data as follows:

μ_1 : Population Mean of Sample 1

μ_2 : Population Mean of Sample 2

Difference: $\mu_1 - \mu_2$

In this study, the following hypotheses were formulated to assess the differences in future skills required for the APMI between Sample 1 and Sample 2:

Where:

Null Hypothesis (H_0): $\mu_1 - \mu_2 = 0$

There is no significant difference in the future skills required for the APMI between Sample 1 and Sample 2.

Alternative Hypothesis (H_1): $\mu_1 - \mu_2 \neq 0$

There is a significant difference in the future skills required for the APMI between Sample 1 and Sample 2.

The test was conducted at a significant level of 0.05. Since the P-value > 0.05, the result indicates no statistically significant difference between the two samples.

4. Results

4.1. Results of expectations for future skills in the APMI

The analysis of data regarding expectations for future skills in the APMI was conducted based on interviews with a sample of 40 participants currently working in the industry. The results are as follows:

Part 1: Personal Data of Interviewees

The demographic data of the respondents were analyzed using frequency and percentage calculations, yielding the following results:

Gender: 24 males (60%) and 16 females (40%)

Age distribution: 12 participants aged 25–35 years (30%), 15 participants aged 36–45 years (37.5%), 8 participants aged 46–55 years (20%), and 4 participants aged over 55 years (10%)

Educational level: 25 participants with a bachelor's degree (62.5%) and 15 with a master's degree (37.5%)

Work experience: 26 participants with 5–10 years of experience (65%) and 14 participants with more than 10 years (35%)

Job position: 18 participants in managerial roles (45%) and 22 participants as engineers (55%)

Industry tier classification: 26 participants working in Tier 1 automotive parts manufacturers (65%) and 14 in Tier 2 manufacturers (35%)

Part 2: Interview Questions Analysis: The interview questions were analyzed using a combination of content analysis and inductive analysis. The data were then categorized into expected skills, separated into professional skills and soft skills. Frequency and percentages were calculated, and the levels of skill expectation were interpreted on a five-level scale. The detailed analysis results are presented in Table 3.

Table 3. Analysis Results of Future Skills Expectations for the APMI Based on In-Depth Interviews

Skill	Frequency	Percentage (%)	Level of Expectation
Professional Skills			
1. Production Automation System	38	95.00	Very High
2. Quality Control and Standards for the Automotive Industry	36	90.00	Very High
3. Welding Technologies and Quality Inspection for Automotive Parts	34	85.00	Very High
4. Engineering Materials for Automotive Components	33	82.50	High
5. Artificial Intelligent	32	80.00	High
6. Battery Technologies for Electric Vehicles	31	77.50	High
7Metal Forming and Die Design	30	75.00	High
Soft Skills			
1. Problem Solving Skill	39	97.50	Very High
2. Collaboration Skill	37	93.33	Very High
3. Communication Skill	36	90.00	Very High
4. Creativity	35	87.50	Very High

According to Table 3, which presents the analysis of future skill expectations for the APMI, the findings indicate that the expected skills are categorized into two main areas: Professional Skills and Soft Skills. The skills most highly expected by industrial establishments include Problem-Solving Skill (97.50%), Production Automation System (95.00%) Collaboration Skill (93.33%), Quality Control and Standards for the Automotive Industry (90.00%) Communication Skill (90.00%), Creativity (87.50%) and Welding Technologies and Quality Inspection for Automotive Parts (85.00%). These were all rated at the highest level of expectation. In addition, the skills rated at a high level of expectation include Engineering Materials for Automotive Components (82.50%), Artificial Intelligence (80.00%) Battery Technologies for Electric Vehicles (77.50%) and Metal Forming and Die Design (75.00%)

4.2. Results of the development of OBEM with a blended learning approach

The learning outcomes were developed based on the levels of learning and action verbs from Bloom's Taxonomy. The skills identified for inclusion as learning outcomes in the OBEM were selected from those with a high level of industry expectation ($\geq 75\%$). These skills were set as key learning targets in the development of the OBEM. The details are presented in Table 4.

Table 4. Future skills expected by industry and the derived learning outcomes

Skill	Learning Outcomes
Professional Skills	
1. Production Automation System	1. Performed basic calculations related to the application of automation systems in industrial settings. 2. Conducted practical operations involving pneumatic and electro-pneumatic control, as well as programmable logic controller (PLC)-based command systems.

	3. Developed programs and established communication interfaces between human and machine (MHI), including integration with the Internet of Things (IoT).
2. Quality Control and Standards for the Automotive Industry	1. Applied statistical tools to support quality control and problem-solving in industrial settings. 2. Identified the core components of the IATF 16949 standard. 3. Interpreted key clauses of the standard, including Context of the Organization, Leadership, Planning, and Support.
3. Welding Technology and Quality Inspection for Automotive Components	1. Appropriate selection of welding parameters 2. Development of welding procedure specifications (WPS) 3. Write a control program for industrial welding robots 4. Inspection of weld quality according to standards
4. Engineering Materials for Automotive Components	1. Describe and compare the material and mechanical properties
5. Artificial Intelligent	1. Analyze and compute data from assigned tasks by applying Artificial Intelligence (AI) techniques. 2. Propose strategies for improving industrial manufacturing efficiency by integrating AI applications.
6. Battery Technologies for Electric Vehicles	1. Select and prepare battery cells for assembly in accordance with technical manuals and safety guidelines 2. Assembled battery modules or packs correctly based on engineering design specifications 3. Testing the performance characteristics of battery modules or packs in accordance with relevant standards
7. Others: Metal Forming, Molds, etc.	1. Utilized software tools to simulate metal forming behavior 2. Selected appropriate dies for the manufacturing of automotive components
Soft Skills	
1. Problem Solving Skill	1. Analyzed the root causes of problems occurring in the manufacturing process of automotive components 2. Proposed effective solutions to address issues in the production process of automotive parts
2. Collaboration Skill	1. Demonstrated active participation in team-based tasks to achieve shared objectives effectively and efficiently
3. Communication Skill	1. Effectively communicate and present information related to automotive parts manufacturing technology to others

4. Creativity

1. Select and integrate knowledge from diverse sources to develop innovative solutions for addressing problems in automotive parts manufacturing.

Table 5. Evaluation results on the appropriateness of the OBEM content “Automotive parts manufacturing for the future automotive industry”

Assessment Items	X	SD	Level
1. Principles and Necessity of the Outcome-Based Education Module (OBEM)	4.80	0.44	Very high
2. Learning Outcomes	4.60	0.89	Very high
3. Content	4.60	0.54	Very high
4. Learning Methods	4.40	0.54	High
5. Learning Materials	4.40	0.54	High
6. Supporting Documents	4.40	0.89	High
7. Assessment	4.60	0.54	Very high

From Table 5, five experts in curriculum and content, as well as education and teaching, evaluated the quality of the OBEM details. The principles and necessity of the OBEM received the highest mean score ($\bar{X} = 4.80$, $SD = 0.44$), indicating an evaluation at the highest level of appropriateness. The learning outcomes, content, and assessment components were also rated at the highest level, respectively. Meanwhile, the learning methods, learning materials, and supporting documents received evaluations at a high level.

Regarding the screening of the OBEM by seven experts, a unanimous consensus was reached to approve the OBEM. However, several recommendations were made to enhance the completeness of the OBEM. The researcher has accordingly implemented revisions based on the experts’ feedback as follows:

1. The researcher reviewed the language usage to ensure appropriateness, clarifying ambiguous expressions for better understanding and correcting various typographical errors.

2. The problem statement and necessity of the OBEM were revised to provide clearer details, effectively reflecting the background and conceptual framework for the development of the OBEM.

3. The level of learning and Action Verbs were adjusted to align with the required skill demands and to facilitate effective assessment.

4. Content within each module was found to overlap with multiple topics in existing courses. Therefore, the content was reviewed and reorganized to improve clarity and relevance, ensuring consistency with the allotted timeframe and the skill requirements of stakeholders. This prepares students adequately before engaging in integrated learning combined with workplace training.

5. The learning methods and instructional media were modified to correspond with the revised content and timeframe.

6. The assessment tools were refined by revising the wording of achievement test questions and skill evaluation instructions to enhance suitability and clarity.

Table 6. Details of the OBEM “Automotive parts manufacturing for the future automotive industry”

Principles and Necessity of the OBEM “Automotive parts manufacturing for the future automotive industry”

1. The OBEM was developed to align with the competency expectations of industry stakeholders.
2. The OBEM employs a blended learning approach, emphasizing student engagement through online learning, classroom instruction, workplace training, and hands-on activities designed to enhance experiential learning.
3. The OBEM was designed to prepare students for integrated learning in collaboration with workplace training within industry settings.

Module 1: Quality control and standards for the automotive industry

Outcome learning	Content	Blended Learning method
1 . The application of statistical tools as instruments to assist in quality control and problem-solving within industry.	1. Concepts of product quality control and process quality control (Face-to-Face: Site visit at an industrial facility, 6 h; Online: 3 h)	Total instructional Time: 24 h 1. Online Teaching (E-learning): 8 h 2. Face-to-Face Teaching: 16 h - Lectures with case studies and group activities: 10 h - Industrial site visit: 6 h
2. Analyzing the root causes of problems occurring in the automotive parts manufacturing process.	2. Application of statistical tools for quality control and problem solving in industry (Face-to-Face: 6 h)	Learning Materials: 1. E-learning 2. Video clips 3. PowerPoint
3. Able to propose solutions to address issues arising in the automotive parts manufacturing process.	3. Principles of IATF 16949 standard requirements (Online: 2 h)	Supporting Documents: 1. Learning materials 2. Worksheets 3. In-class exercises
4 . Able to identify the components of the IATF 16949 standard requirements.	4. Requirements of the IATF 16949 Standard (Online: 3 h)	
5. Capable of interpreting the requirements related to the Context of the Organization, Leadership, Planning, and Support.	5. Interpretation of Requirements: Context of the organization, Leadership, Planning, and Support (Face-to-Face: 4 h)	
6 . Demonstrates effective teamwork to achieve designated goals.		
7 . Communicates and presents information regarding automotive parts manufacturing technology to others effectively.		

Module 2: Intelligent manufacturing systems for automotive parts production

Outcome learning	Content	Blended Learning method
1. Perform data calculations from assigned tasks by applying artificial intelligence techniques.	1. Artificial intelligence in industrial engineering (Online, 3 h)	Total Instructional Time: 24 h 1. Online Learning (E-learning): 8 h 2. Face-to-Face Instruction: 16 h - Lectures with case studies and group activities: 4 h - Practical training on pneumatic and electropneumatic control
2 . Propose process improvement strategies to enhance industrial production efficiency by	2. Application of Artificial Intelligence to Improve Processes, Enhance Efficiency, and Solve Industrial Problems (Online, 2 h; Face-to-Face, 4 h)	

reducing manufacturing errors through the application of artificial intelligence.	3. Principles and Basic Calculations for the application of automation systems in Industrial Factories (Online, 3 h)	circuits, and Programmable Logic Controller (PLC) systems: 6 h
3 . Conduct fundamental calculations related to the application of automation systems in industry.	4. Practical operations on pneumatic, electropneumatic control circuits, and programmable logic controller (PLC) Systems (Face-to-Face, 6 h)	Practical training on programming and integrating communication systems between Man-Machine Interface (MHI) and the Internet of Things (IoT): 6 h
4 . Operate pneumatic, electropneumatic, and programmable logic controller (PLC)-based control systems.	5. Practical programming and communication integration between man-machine interface (MHI) and the internet of things (IoT) (Face-to-Face, 6 h)	Learning Materials:
5. Develop programming and establish communication interfaces between humans and machines (MHI) as well as the Internet of Things (IoT).		1. E-learning
6 . Select knowledge from diverse information sources to creatively develop innovative solutions for problems in manufacturing automotive parts.		2. Video clips
7 . Participate effectively in teamwork to achieve project objectives.		3. PowerPoint
		Supporting Documents:
		1. Course materials
		2. Worksheets
		3. In-class exercises

Module 3: Engineering materials and metal forming for automotive parts manufacturing

Outcome learning	Content	Blended Learning method
1. Explain and compare the material properties and mechanical characteristics of materials used in automotive parts manufacturing.	1. Engineering materials for automotive parts manufacturing (Online, 3 h)	Total instruction time: 12 h 1. Online Instruction (E-learning): 4 h 2. Face-to-Face Instruction: 8 h - Lectures with case studies and group presentations: 4 h - Practical training on using software to simulate metal forming behavior: 4 h Learning Materials: 1. E-learning 2. Video clips 3. PowerPoint Supporting Documents: 1. Learning materials 2. Worksheets 3. In-class exercises
2. Utilize software to simulate metal forming behavior.	2. Software for simulating metal forming behavior (Face-to-Face, 6 h)	
3. Select appropriate molds for the production of automotive parts.	3. Molds for production of automotive parts (Online, 1 hour; Face-to-Face, 2 h)	
4. Communicate and present information regarding automotive parts manufacturing technology to others effectively.		

Module 4: Welding technology and quality inspection for automotive parts

Outcome learning	Content	Blended Learning method
1 . Select appropriate parameters for welding automotive parts accurately. 2 Develop welding procedure specifications (WPS) in accordance with established welding standards. 3 . Program robotic welding movements for industrial robots according to specified requirements. 4 . Inspect weld quality to ensure compliance with applicable standards. 5 . Analyze root causes of issues arising during the automotive parts manufacturing process.	1. Welding processes for automotive assembly (Online, 3 h) 2. Welding standards for automotive parts (Online, 1 hour; Face-to-Face, 2 h) 3. Industrial robotic welding (Online, 2 h) 4. Programming motion for industrial welding robots (Face-to-Face, 6 h) 5. Weld quality inspection (Face-to-Face, 4 h)	Total instructional time: 18 h 1. Online instruction: 6 h (E-learning) 2. Face-to-face instruction: 12 h - Practical training on writing Welding Procedure Specification (WPS): 2 h - Practical training on programming motion for industrial welding robots: 6 h - Practical training on weld quality inspection and failure analysis in welding: 4 h Learning materials: 1. E-learning 2. Video clips 3. PowerPoint Supporting documents: 1. Course materials 2. Worksheets 3. In-class exercises

Module 5: Battery technology for electric vehicles

Outcome learning	Content	Blended Learning method
1. Select and prepare battery cells for assembly according to the specified manual. 2. Assemble battery cells into modules or packs accurately following design specifications. 3. Test the characteristics of battery modules or packs in accordance with established standards.	1 . Batteries for electric vehicle applications (Online, 1 hour) 2. Selection and preparation of battery cells for assembly (Online, 1 hour; Face-to-Face, 3 h) 3. Assembly of battery cells into modules or packs (Online, 1 hour; Face-to-Face, 3 h) 4. Testing of battery module or pack characteristics (Online, 1 hour; Face-to-Face, 3 h)	Total Instructional Time: 12 h 1 . Online Teaching: 4 h (E-learning) 2. Face-to-Face Teaching: 8 h - Practical training on selection and preparation of battery cells for assembly: 3 h - Practical training on battery assembly into modules or packs: 3 h - Practical training on testing the characteristics of battery modules or packs: 2 h Learning Materials: 1. E-learning 2. Video clips 3. PowerPoint Supporting Documents: 1. Learning materials 2. Worksheets 3. In-course exercises

Evaluation	1. The achievement test for the OBEM titled “<i>Automotive Parts Manufacturing for the Future Automotive Industry</i>” consists of 55 multiple-choice questions, each with four options. The total assessment duration is 1 h. 2 The practical skill assessment for the OBEM titled “<i>Automotive Parts Manufacturing for the Future Automotive Industry</i>” comprises five evaluation components with a total assessment duration of 3.5 h, as follows: - Assessment of problem-solving presentation using quality tools (0.20 h) - Assessment of control commands using Programmable Logic Controllers (PLC) and Internet of Things (IoT) connectivity (1 h) - Assessment of metal forming behavior simulation using specialized software (0.30 h) - Assessment of automotive parts welding using industrial welding robots and weld quality inspection (1 h) - Assessment of battery cell preparation, module or pack assembly, and battery performance testing (1 h)
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The evaluation of the OBEM content by subject matter experts resulted in unanimous approval, with all experts providing constructive feedback to further refine the module's completeness. These suggestions were incorporated, and the final version is detailed in Table 6. The OBEM, titled "Automotive parts production for the future automotive industry," comprises five distinct modules: Module 1, Quality control and standards for the automotive industry; Module 2, Smart production systems for automotive parts manufacturing; Module 3, Engineering materials and metal forming for automotive Parts; Module 4, Welding technology and quality inspection for automotive parts; and Module 5, Battery technology for electric vehicles. The module framework consists of seven key components: 1) Principles and necessity of OBEM, 2) Learning Outcomes, 3) Content, 4) Learning Methods, 5) Learning Media, 6) Supporting Documents, and 7) Assessment. The instructional approach employs a blended learning method, comprising a total of 90 contact hours, subdivided into 30 hours of theoretical content delivered via online lessons (as shown in Figure 3) and 60 hours of face-to-face instruction. Evaluation of student performance comprises both achievement testing and practical skill assessments, ensuring comprehensive measurement of learning outcomes.



Figure 3. An example of an online lesson from the OBEM “Automotive parts manufacturing for the future automotive industry.”

Table 7. Analysis of the Effectiveness of the OBEM “Automotive Parts Manufacturing for the Future Automotive Industry”

Module	Efficiency Value	Interpretation of Results
1. Quality Control and Standards in Automotive Manufacturing	$E_1 = 79.43$	Satisfy the standard
	$E_2 = 77.95$	Satisfy the standard
2. Intelligent Manufacturing Systems in the Automotive Parts Industry	$E_1 = 78.33$	Satisfy the standard
	$E_2 = 77.72$	Satisfy the standard
3. Engineering Materials and Metal Forming for Automotive Manufacturing	$E_1 = 77.23$	Satisfy the standard
	$E_2 = 78.00$	Satisfy the standard
4. Advanced Welding and Inspection Technologies in Automotive Parts Manufacturing	$E_1 = 78.46$	Satisfy the standard
	$E_2 = 77.14$	Satisfy the standard
5. Advanced Battery Technologies for Electric Mobility	$E_1 = 76.75$	Satisfy the standard
	$E_2 = 77.50$	Satisfy the standard

As shown in Table 7, the effectiveness of the OBEM on "Automotive parts production for the future automotive industry" was evaluated based on the E_1/E_2 efficiency criteria, where E_1 represents the students' average score from learning activities and E_2 denotes the average score from the post-learning achievement test. The results indicated that all modules met the required effectiveness standards. Specifically, the module 'Quality Control and Standards for the Automotive Industry' achieved an E_1/E_2 value of 79.43/77.95. The smart production systems for automotive parts manufacturing module recorded an E_1/E_2 value of 78.33/77.72. The engineering materials and metal forming for automotive parts module yielded an E_1/E_2 value of 77.23/78.00. The welding technology and quality inspection for automotive parts module demonstrated an E_1/E_2 value of 78.46/77.14. Lastly, the battery technology for electric vehicles modules had an E_1/E_2 value of 76.75/77.95.

4.3. Results of the study on the effectiveness of the OBEM combined with a blended learning approach on future skills for the APMI

The study investigated the effectiveness of the OBEM integrated with a blended learning approach in enhancing future skills among students preparing for careers in the APMI. The effectiveness was assessed by comparing post-learning average scores between two groups: Group 1, the experimental group, received instruction through the OBEM and blended learning approach, while Group 2, the control group, engaged in traditional learning methods. As illustrated in Figure 4, the evaluation focused on practical skills related to modern automotive parts production. The students' performance was converted into percentages and interpreted based on a predetermined criterion score, with 75.00% set as the benchmark for a "good" level of expected skill proficiency.



Figure 4. The hands-on training activities of students in Experimental Group 1 involved learning through the OBEM, combined with a blended learning approach.

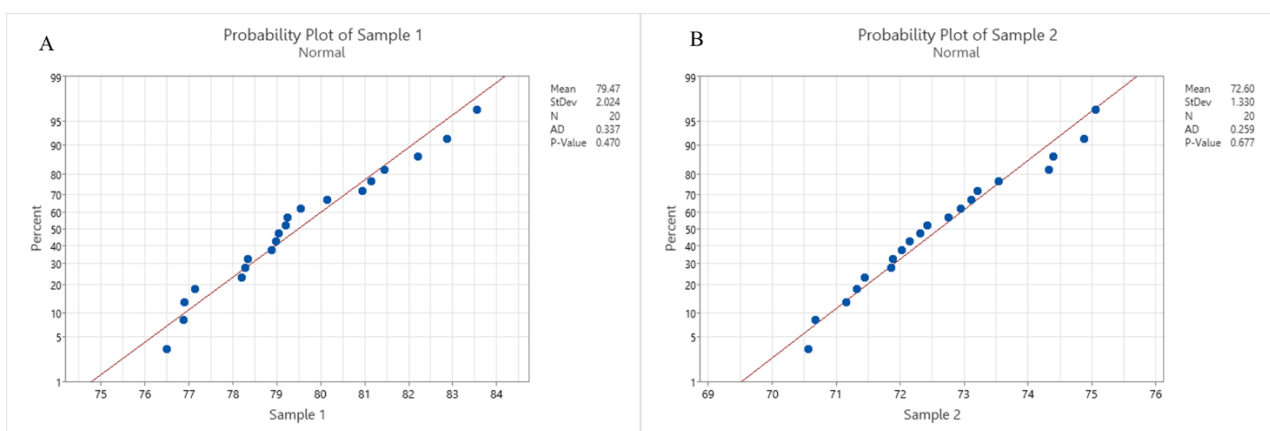


Figure 5. Probability plot of sample 1 and 2

Figure 5 illustrates the distribution of post-test scores for both sample group 1 and sample group 2. The result indicated that sample group 1 ($N = 20$), the post-test scores followed a normal distribution ($P\text{-value} = 0.470$) with a mean score of 79.47%. All students in this group achieved post-test scores above 75%, which meets the expected proficiency threshold. As shown in Figure 2A, all participants in this group demonstrated performance classified at a "good" level based on the future skills criteria for the APMI.

For sample group 2 ($N = 20$), the post-test scores also exhibited a normal distribution ($P\text{-value} = 0.677$) with a mean score of 72.60%. However, the results indicate that 19 out of 20 students scored below the expected threshold, while only one student exceeded the expected proficiency level.

Table 8. Comparison of academic achievement between students learning with the OBEM combined with the blended learning method and students learning with the conventional learning method

Sample	N	Mean	S.D.	SE. Mean	DF	T-Value	P-Value
Sample 1	20	79.47	2.02	0.45	32	12.69	0.00
Sample 2	20	72.60	1.33	0.30			

According to Table 8, students who participated in learning through the OBEM combined with a blended learning approach (sample 1) achieved a mean score of 79.47 with a standard deviation (S.D.) of 2.02. In contrast, students who received conventional instruction (sample 2) had a mean

score of 72.60 with a standard deviation of 1.33. Statistical analysis revealed a P-value of 0.00, indicating a statistically significant difference in scores between the two groups at the 0.05 level of significance ($P < 0.05$).

These findings support the research hypothesis $H_1: \mu_1 - \mu_2 \neq 0$, confirming that there is a significant difference in the development of future skills for the APMI between students who learned through OBEM with blended learning and those who received traditional instruction.

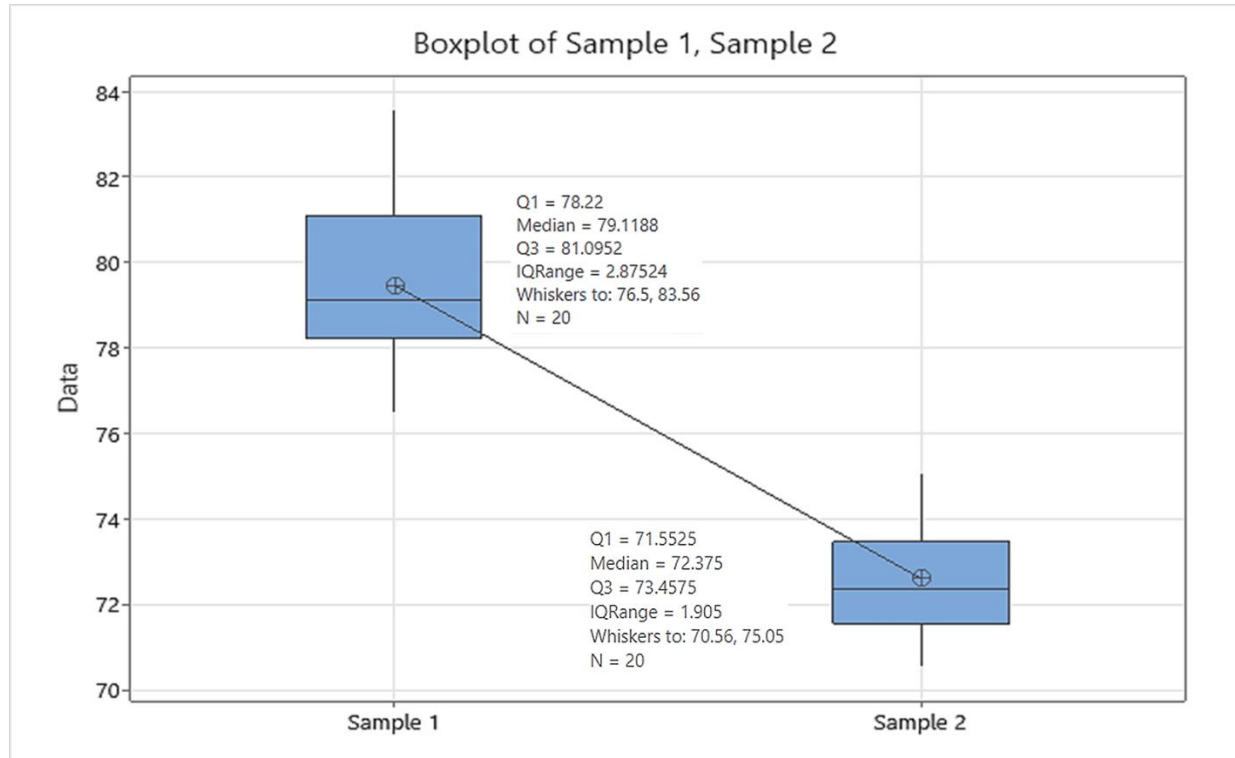


Figure 6. Box plot of sample 1 and 2

According to Figure 6, the distribution of scores and score levels of Sample Group 1 show a median score of 79.11, with Quartile 1 (Q1) at 78.22 and Quartile 3 (Q3) at 81.09, resulting in an interquartile range (IQR) of 2.87. The whiskers, which represent the thresholds for potential outliers, are calculated at 76.50 (lower bound) and 83.56 (upper bound). It was found that the scores of Sample Group 1 were within the normal range, with no outliers identified.

For sample group 2, Q1 was 71.55 and Q3 was 73.45, yielding an IQR of 1.90. The whisker boundaries were determined to be 70.56 and 75.05, respectively. The results indicate that all scores in Sample Group 2 also fell within the normal range.

5. Discussion

The findings from the in-depth interviews with professionals in the APMI reveal that future skills required in this sector can be categorized into two main domains: professional skills and soft skills. The most highly expected competencies by the industry include problem-solving skills, production automation systems, collaboration skills, quality control and standards for the automotive industry, communication skills, creativity, and welding and quality inspection technology for automotive parts (85.00%). Additionally, other competencies highly expected by industry stakeholders include engineering materials for automotive parts (82.50%), artificial intelligence (80.00%), battery technology for electric vehicles (77.50%), and metal forming and tooling technology (75.00%).

These findings are consistent with previous studies. Klinpong (2020) suggested that the workforce in Thailand's automotive industry must have capabilities in digital skills, data analysis, and

the capacity to work with automated technology to fulfill the needs of Industry 4.0. Likewise, et al. (2021) emphasized that future skills encompass both skills and attitudes. The Organization for Economic Co-operation and Development (OECD, 2019) further proposed that future competencies comprise knowledge, skills, and attributes, guiding educational design toward equipping learners with abilities aligned with global development trends and industry demands.

Based on the identified future skill requirements, learning outcomes were developed to reflect observable, measurable competencies aligned with instructional methods, activities, assessments, and real-world industry needs (Hristov, Nakov, & Miocinovic, 2023; Lasrado & Kaul, 2021). These learning outcomes informed the development of the OBEM titled: "Automotive parts production for the future automotive industry", designed following the principles of Constructive Alignment (Biggs, Tang, & Kennedy, 2022). The OBEM aims to equip students with future-relevant competencies through a work-integrated learning approach. The OBEM comprises five modules: 1) Quality control and standards for the automotive industry, 2) Intelligent production systems for automotive parts, 3) Engineering materials and metal forming for automotive parts, 4) Welding and quality inspection technology for automotive parts, and 5) Battery technology for electric vehicles.

The OBEM was reviewed by subject-matter experts to assess its appropriateness. The evaluation results indicated the highest level of agreement for its principles and rationale, learning outcomes, content, and assessment approaches. The instructional methods, learning materials, and supporting documents were rated as highly appropriate. Additionally, the OBEM was presented to a screening committee of seven experts who unanimously approved the module, affirming its academic rigor and alignment with the Constructive Alignment framework, as described by Abejuela et al. (2022). This study evaluates the alignment of institutional outcomes, program outcomes, assessment methodologies, and standards across 20 undergraduate courses, emphasizing the significance of cohesive curriculum design. In addition, Hamdoun (2023) reported that constructive alignment in higher education advocates for a change away from traditional, teacher-centered practices and toward student-centered learning.

The OBEM titled "Automobile parts manufacturing for the future automotive industry" was evaluated for its instructional effectiveness with a group of 20 third-year students enrolled in the Bachelor of Technology Program in Industrial Technology, who were not part of the main study sample. The evaluation followed the process-outcome efficiency criterion (E1/E2), with a minimum threshold set at 75/75 percent. The efficiency scores were calculated using students' performance on the skill assessment conducted during the OBEM learning process (E1) and the post-learning skill assessment (E2). The results showed that all modules met or exceeded the specified criteria.

The researcher investigated the learning outcomes of two groups of undergraduate students to determine the efficiency of the OBEM combined with a blended learning method in developing future abilities required in the automobile parts manufacturing sector study. Group 1, which received instruction through OBEM combined with blended learning, and Group 2, which received instruction through traditional teaching methods. The findings revealed that the post-test scores for both groups were normally distributed ($P\text{-value} > 0.05$). Group 1 achieved an average post-test score of 77.94%, which was higher than the expected performance benchmark of 75%, indicating successful attainment of the targeted skills. In contrast, Group 2 obtained an average post-test score of 70.84%, which was below the expected level. These results suggest that the OBEM integrated with blended learning is more effective in promoting the development of future-oriented skills compared to conventional instructional methods, according to Rahimzadeh and Gilakjani (2022), who studied the impact of blended learning on Iranian intermediate EFL learners' reading competency and discovered that the experimental group employing blended learning strategies outperformed the control group in reading comprehension. In addition, Yu and Sukjairungwattana (2022) concluded that blended learning results are significantly greater than traditional learning outcomes, with a medium impact

size. Learners have much more positive sentiments regarding blended learning than traditional learning.

The analysis of score distribution and performance levels among the participants in Group 1 revealed a wider spread of scores compared to Group 2. This broader distribution can be attributed to the nature of the blended learning approach, which allows students to select learning methods that best suit their individual preferences and learning styles. As a result, variations in students' adaptability to different modes of learning contributed to the wider range of performance. Some students performed particularly well in the online learning components, while others excelled in the hands-on practical sessions. This indicates that the flexibility inherent in blended learning can support diverse learner needs but may also lead to increased variability in academic outcomes. According to Bondarenko et al. (2019), geography students who used Google Classroom for blended learning achieved a wider range of academic outcomes over three years. The combination of online and in-class components enabled students to participate at their own pace, resulting in a wider distribution of scores.

In the traditional learning setting (Group 2), the distribution of scores was narrower and more clustered. This pattern is attributed to the standardized instructional approach and uniform assessment methods applied to all students. While this method ensures consistency, it may not cater to the diverse learning needs and preferences of all learners. As a result, students with varying levels of engagement and learning styles may experience different levels of success in assignments or examinations. Geng et al. (2021) discovered that students utilizing Learning Management Systems (LMS) had moderate variability in performance scores, which was influenced by both instructional methods and individual student variables. This shows that traditional techniques can provide a variety of results, with some students flourishing while others struggle, depending on their participation and adaptation to the teaching strategy.

The comparison of learning achievement between Group 1 and Group 2 revealed a statistically significant difference at the 0.05 level ($P\text{-value} < 0.05$), consistent with the research hypothesis $H_1: \mu_1 - \mu_2 \neq 0$. This indicates that the future skills related to the APMI differed significantly between Sample 1 and Sample 2. The observed difference can be attributed to the blended learning approach, which promotes personalized learning and self-directed study. By accommodating individual learning preferences, blended learning enhances the diversity of learning outcomes among students. This finding aligns with studies conducted in several countries, which have consistently demonstrated the positive effects of blended learning methods on students' academic performance.

As reported by Al-Zahrani and Al-Shboul (2024), a statistically significant difference was found between the mean post-test scores of students in the experimental group and the control group, with the experimental group—taught through blended learning—achieving higher scores. This result suggests that the implementation of blended learning had a positive impact on students' academic achievement in the subject Computer Programming for Children. Similarly, the study by López-Reyes et al. (2022) concluded that blended learning had a positive impact on the learning outcomes of engineering students in the subject of Differential Mathematics. The approach contributed not only to students' acquisition of knowledge and technical skills but also to the development of social competencies, all of which are critical for professional growth in the field of engineering. Therefore, it can be concluded that implementing an Outcome-Based Education Module (OBEM) in combination with blended learning is an effective strategy for enhancing future skills among students in the APMI. The OBEM model serves as a preparatory framework for equipping students with future-oriented competencies before they engage in integrated work-based learning experiences within industrial settings.

Finally, while the study strongly advocates for blended learning as a future-oriented pedagogical strategy within APMI, a critical reflection suggests that further research is needed to optimize blended modalities, balancing flexibility with consistent competency attainment, thereby addressing the observed heterogeneous learner profiles. Overall, this study makes a theoretical and practical contribution to education-industry integration by highlighting the need for tailored, constructively integrated curricula, combined with innovative teaching methodologies, in educating students to address emerging industrial concerns.

6. Conclusion

The development of future skills for students in the APMI through the implementation of an OBEM combined with a blended learning approach has proven to be an effective strategy in preparing students for work-integrated learning in industrial settings. The study concludes that the essential future skills for this industry can be categorized into two main domains: 1) Professional Skills, which include: Production Automation Systems, Quality Control and Standards for the Automotive Industry, Welding and Quality Inspection Technology for Automotive Parts, Engineering Materials for Automotive Parts, Artificial Intelligence, Battery Technology for Electric Vehicles, Metal Forming and Tooling Technology and Soft Skills, which encompass Problem-Solving Skills, Collaboration Skills, Communication Skills, Creativity

Based on the skill demands identified from industry stakeholders, the OBEM was developed to include five instructional modules, specifically designed to align with industry requirements and future competencies. These modules are Module 1: Quality control and standards for the automotive industry, Module 2: Intelligent production systems for automotive parts, Module 3: Engineering materials and metal forming for automotive parts, Module 4: Welding and quality inspection technology for automotive parts, and Module 5: Battery technology for electric vehicles

The OBEM was delivered using a blended learning approach, integrating online theoretical instruction with face-to-face practical sessions. The results demonstrate that students who participated in the OBEM-based blended learning environment developed significantly higher levels of future skills relevant to the APMI, compared to those who engaged in traditional learning methods.

7. Suggestion

Educational institutions implementing work-integrated learning programs are encouraged to utilize the findings of this research to design undergraduate courses or develop preparatory training programs aimed at equipping students with essential skills prior to their professional internships. Integrating these research-based modules into the curriculum can enhance students' readiness for workplace learning and ensure that their competencies align with the demands of the APMI. Furthermore, the application of these findings can support students in developing future-oriented skills prior to graduation, thereby increasing their employability and responsiveness to industrial needs.

Declarations

Author Contributions. Peasura: Conceptualization, Design systems, Data analysis, Writing, Editing, Supervision; Moolsradoo: Design systems, Data analysis, Editing; Sopha: Design systems, Data analysis, Writing; Lerthiranphanya: Data analysis, Writing, and Kasuriya: Data analysis, Writing.

Conflicts of Interest. The authors declare no conflict of interest with other research

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Data Availability Statement. (Please provide a statement about where data supporting the results reported in this study)

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References

- Abejuela, H. J. M., Castillon, H. T., & Sigod, M. J. G. (2022). Constructive alignment of higher education curricula. *Asia Pacific Journal of Social and Behavioral Sciences*, 20. <https://doi.org/10.57200/apjsbs.v20i0.288>.
- Allen, I. E., & Seaman, J. (2013). *Changing course: Ten years of tracking online education in the United States*. Babson Survey Research Group. <https://www.onlinelearningsurvey.com/reports/changingcourse.pdf>.
- Al-Zahrani, H. A., & Al-Shboul, M. A. (2020). The Effect of Using Blended Learning on Achievement among the Students of Child Computerized Programs Courses in the Faculty of Educational Sciences at The University of Jordan. *Jordanian Educational Journal*, 9(1), 1–16. <https://doi.org/10.46515/jaes.v9i1.469>.
- Asean automotive federation. (2022). *Asean automotive statistics as at december 2022*. Asean automotive federation. <https://www.asean-autofed.com/statistics.html>.
- Biggs, J., & Tang, C. (2011). *Teaching for Quality Learning at University (4th ed.)*. McGraw-Hill Education.
- Bondarenko, O., Mantulenko, S., & Pikilnyak, A. (2019). *Google Classroom as a tool of support of blended learning for geography students*. arXiv preprint arXiv:1902.00775.
- Casper, R. (2021). Automotive Remanufacturing in a Changing Market: Challenges and Opportunities in a market with a growing share of electric cars. <https://doi.org/10.3384/diss.diva-180947>.
- Casper, R., & Sundin, E. (2021). Electrification in the Automotive Industry: Effects on Remanufacturing. *Journal of Remanufacturing*, 11, 121-136. <https://doi.org/10.1007/s13243-020-00094-8>.
- Dondi, M., Klier, J., Panier, F., & Schubert, J. (2021). Defining the skills citizens will need in the future world of work. *McKinsey & Company*, 25, 1-19.
- Fergusson, L., van der Laan, L., Imran, S., & Ormsby, G. (2021). The development of work-integrated learning ecosystems: An Australian example of cooperative education. *International Journal of Work-Integrated Learning*, 22(1), 25–40. https://www.ijwil.org/files/IJWIL_22_1_25_40.pdf.
- Garcia, R. E., Abaratigue, A. M., & Alcantara, N. V. (2021). Integration of learning management system as an aid in teaching: An assessment. *European Journal of Educational Research*, 10(4), 1907–1918. <https://doi.org/10.12973/eu-jer.10.4.1907>.
- Ghannam, R., & Chan, C. (2023). Teaching undergraduate students to think like real-world systems engineers: A technology-based hybrid learning approach. *Systems Engineering*, 26(6), 728–741. <https://doi.org/10.1002/sys.21612>

- Graham, C. R. (2006). Blended learning systems: Definition, current trends, and future directions. In C. J. Bonk & C. R. Graham (Eds.), *Handbook of blended learning: Global perspectives, local designs* (pp. 3–21). San Francisco, CA: Pfeiffer.
- Hamdoun, W. M. A. (2023). Constructive Alignment Approach: Enhancing Learning and Teaching *British Journal of Multidisciplinary and Advanced Studies*, 4(2), 162–170. <https://doi.org/10.37745/bjmas.2022.0173>.
- Hamidi, H., Hejran, A. B., Sarwari, A., & Edigeevna, S. G. (2024). The Effect of Outcome Based Education on Behavior of Students. *European Journal of Theoretical and Applied Sciences*, 2(2), 764-773. [https://doi.org/10.59324/ejtas.2024.2\(2\).68](https://doi.org/10.59324/ejtas.2024.2(2).68).
- Hristov, S., Nakov, D., & Miočinović, J. (2023). Constructive alignment between objectives, teaching and learning activities, student competencies and assessment methods in higher education. *Journal of Agriculture and Plant Sciences*, 21(2), 21-36. <https://doi.org/10.46763/JAPS23212021h>.
- Jackson, D., Dean, B. A., & Eady, M. (2023). Equity and inclusion in work-integrated learning: participation and outcomes for diverse student groups. *Educational Review*, 77(2), 329–350. <https://doi.org/10.1080/00131911.2023.2182764>
- Jebba, M. M., Nordin, M. S., Onyilo, I. R., & Quadri, A. T. (2024). Employability Skill Development of Automobile Technology Students in a Work-Integrated Learning Environment: Barriers and Best Practices. *International Journal of Academic Research in Progressive Education and Development*, 13(3), 1169–1179. <https://www.ajol.info/index.php/kje/article/view/293221>.
- Klinpong, S. (2020). *Thai labor skills knowledge and HRD roles for the automotive industry to comply with Industrial Revolution 4.0* (Doctoral dissertation, Burapha University).
- Lasrado, F., & Kaul, N. (2021). Designing a curriculum in light of constructive alignment: A case study analysis. *Journal of Education for Business*, 96(1), 60–68. <https://doi.org/10.1080/08832323.2020.1832435>.
- Lasrado, F., Dean, B. A., & Eady, M. J. (2023). Inclusive work-integrated learning in higher education: a scoping review. *Studies in Higher Education*, 49(9), 1588–1609. <https://doi.org/10.1080/03075079.2023.2271048>.
- Lempp, M., & Siegfried, P. (2022). *Automotive Disruption and the Urban Mobility Revolution*. Springer International Publishing. <https://link.springer.com/book/10.1007/978-3-030-90036-6>.
- Li, S., & Wang, W. (2022). Effect of blended learning on student performance in K-12 settings: A meta-analysis. *Journal of Computer Assisted Learning*, 38(5), 1254–1272. <https://doi.org/10.1111/jcal.12696>.
- Lkhagvaa, K., Tsogbadrakh, B., Gochoosuren, G., Badamdorj, O., & Stark, A. (2024). The effect of outcome-based education on clinical performance and perception of pediatric care of the third-year nursing students in Mongolia. *PLoS ONE*, 19(6), e0305298. <https://doi.org/10.1371/journal.pone.0305298>.
- López-Reyes, L. J., Jiménez-Gutiérrez, A. L., & Costilla-López, D. (2022). The Effects of Blended Learning on the Performance of Engineering Students in Mathematical Modeling. *Education Sciences*, 12(12), 931. <https://doi.org/10.3390/educsci12120931>
- OECD. (2019). *An OECD learning framework 2030* (pp. 23–35). Springer International Publishing.
- Popham, W. J. (2021). *Classroom assessment: What teachers need to know* (8th ed.). Pearson Education.

- Prohimi, A. H. A., Syihabudhin, Juariyah, L., Bidin, R., Gunawan, A., & Syafruddin, A. B. (2023). Educational Innovation for Industry 4.0: An Exploration of Integrated Work-Based Learning's Contribution. *Revista De Gestão Social E Ambiental*, 18(3), e04225. <https://doi.org/10.24857/rgsa.v18n3-009>
- Rahimzadeh, L., & Gilakjani, A. P. (2022). Investigating the Effectiveness of Blended Learning in Reading Proficiency: Evidence from Intermediate EFL Learners. *Knowledge Management & E-Learning*, 14(4), 489-509. <https://doi.org/10.34105/j.kmel.2022.14.025>.
- Rady, M., Darwish, M., Abbod, M. F., & Almatrafi, E. (2023, January). *Development of Mechanical Engineers skills for an emerging Electric Vehicles industry* [Conference paper]. International Conference on Mechanical, Automotive and Mechatronics Engineering. <https://doi.org/10.53375/icmame.2023.146>
- Ruwaida, R., & Putu Sudira. (2024). School Partnership Management with Industry and the World of Work to Improve Student Automotive Skills Competency. *Jurnal Pendidikan Dan Pengajaran*, 57(1), 183–194. <https://doi.org/10.23887/jpp.v57i1.61034>.
- Saleet, H., Aldamsah, A., Banikhaled, M., Abu-Baker, A., Damseh, R. A., Al-Smadi, M., Mostafa, A., Adaileh, W., Alahmer, A., Al-Salaymeh, A., Al Twassi, S., AlBeek, R., & Hassouneh, K. (2023). Importance and Barriers of Establishing Educational/Training Programs in Electric Vehicles/Hybrid-Electric Vehicles in Jordan. *World Electric Vehicle Journal*, 14(9), 232. <https://doi.org/10.3390/wevj14090232>.
- Sangrà, A. (2019). *Blended learning: A new education paradigm*. Educause Review. <https://www.educause.edu/review>.
- Saylor, J. G., Alexander, W. M., & Lewis, A. J. (1981). *Curriculum planning for better teaching and learning* (4th ed.). Holt, Rinehart and Winston.
- Tabassum, B., Moin, M., Abbas, Q., Kumbhar, M. I., & Khan, M. H. N. (2024). The impact of blended learning on student performance. *Journal of Education and Social Studies*, 5(2), 360–371. <https://doi.org/10.52223/jess.2024.5217e0305298>. <https://doi.org/10.1371/journal.pone.0305298>
- Tong, D. H., Uyen, B. P., & Ngan, L. K. (2022). The effectiveness of blended learning on students' academic achievement, self-study skills, and learning attitudes: A quasi-experimental study in teaching the conventions for coordinates in the plane. *Heliyon*, 8(12), Article e12345. <https://doi.org/10.1016/j.heliyon.2022.e12345>
- Tucker, B. D., Patel, A. M., & Lee, H. J. (2023). The impact of outcome-based education on vocational education: An analysis of student outcomes and employability. *Journal of Vocational Education & Training*, 75(1), 19-34. <https://doi.org/10.1080/13636820.2022.2057238>
- Vodovozov, V., Raud, Z., & Petlenkov, E. (2022). Active Blended Learning Engineering Students: A Case Study. *Education Sciences*, 12(5), 344. <https://doi.org/10.3390/educsci12050344>
- Yu, Z., Xu, W., & Sukjairungwattana, P. (2022). Title: Meta-analyses of Differences in Blended and Traditional Learning Outcomes and Students' Attitudes. *Journal: Frontiers in Psychology*, 13, 926947 DOI: 10.3389/fpsyg.2022.926947
- Yulianti, D., & Fitriansyah, A. (2024). Employment and skill development initiatives in the labor markets: The cases of Indonesia and Thailand. *Journal of Policy Studies*, 39(1), 41-55. <https://doi.org/10.52372/jps39104>.

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