

Research Article

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A Blended and Competency-Based Learning Model for Enhancing Thai Welders' Skills Aligned with Occupational Standards and Professional Qualifications

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Abstract

Background/purpose. Currently, the Thai industrial sector is facing a shortage of skilled welders. Moreover, those currently in the industrial workforce often lack competencies aligned with professional standards, which adversely affects the nation's international competitiveness. Therefore, the objective of this research is to develop a blended learning model integrated with competency-based learning to enhance welders' competencies in accordance with the occupational standards and professional qualifications of the industrial welding profession in Thailand.

Materials/methods. This study employed a Research and Development (R&D) design, utilizing a mixed-methods research approach. The research process was divided into two phases: Phase 1 focused on developing the learning model, while Phase 2 examined the effectiveness of the implemented model.

Results. This study created the PRO-WELD Model (Professional Welding Education through Learning and Development Aligned with Standards), which consists of six components: principles, objectives, instructional methods, technologies and media, assessment and certification aligned with occupational standards, and roles of instructors and learners. The model achieved E1/E2 scores of 78.35/77.45 and received good approval. PRO-WELD significantly improved welder competencies, allowing them to meet the assessment criteria for Shielded Metal Arc Welder Level 2 official certification.

Conclusion. The results of this study can be used to enhance welders' skills across various processes, ensuring they meet occupational standards and professional qualifications. This will facilitate personal growth and career progression within the welding field.

1. Introduction

The development, promotion, and support of workforce competencies within the industrial ecosystem to align with the demands of employers and enterprises, while also ensuring international relevance and suitability to the Thai context, are critical to national development. This alignment enables Thailand to remain competitive in the global arena, in accordance with the Thailand 4.0 policy and the 20-Year National Strategic Plan (2017–2036) (Office of the National Economic and Social Development Council, 2020). There is a necessity to provide training for personnel in line with occupational standards and professional qualifications to enhance workforce quality and capabilities, enabling them to participate in competency assessments and obtain professional certification. Such measures ensure international competitiveness and contribute to comprehensive and sustainable workforce development within the industrial ecosystem. Personnel in the industrial ecosystem are part of the targeted industries identified in the Integrated Plan for the Development of Future Industries and Services.

At present, the majority of this workforce requires training to align their competencies with occupational standards and professional qualifications. The Thai industrial sector is currently facing a shortage of specialized skilled labor, particularly welders, whose numbers are insufficient to meet industry demand. Moreover, personnel within the industrial ecosystem often lack competencies that align with professional requirements, thereby undermining the nation's global competitiveness (NESDC, 2022; OECD, 2023). According to the Welding Professional Association, Thailand has approximately one million welders, but only 35–40% meet the qualifications necessary for overseas employment. This has led to a shortage of high-quality welders in the domestic market. Therefore, developing workforce competencies in accordance with occupational standards is vital to enhancing Thailand's international competitiveness (Treviño-Elizondo & García-Reyes, 2023; Marlapudi & Lenka, 2024). While labor shortages and the requirement to meet occupational standards are well-known challenges, past research has tended to treat them independently rather than integrating them into a systematic model of learning and competency development that responds directly to industry demands. To bridge this gap, a comprehensive learning framework must be established that integrates competency standards, professional qualifications, and effective pedagogical techniques.

To effectively upgrade workforce competencies in the industrial ecosystem, it is necessary to design appropriate learning models tailored to specific learner groups. Such models ensure that learning outcomes are achieved for each profession, enabling trainees to successfully undergo occupational standards assessments. Blended Learning (BL), which integrates face-to-face interaction between instructors and learners with online learning, has been identified as an effective approach. Online modules provide opportunities for pre-study and review, while face-to-face training focuses on hands-on practice aligned with occupational competency units. Practical training methodologies are crucial for ensuring learners can achieve the required professional outcomes. De Cecco's (1974) skill teaching method, which emphasizes preparation, knowledge presentation, practice to mastery, and evaluation, highlights the importance of structured instructional processes. Similarly, Fitts and Posner's (1967) three-stage skill acquisition model (cognitive, associative, autonomous) provides a framework for designing effective skill-based training. Integrating these pedagogical approaches with BL and Competency-Based Learning (CBL) offers a pathway to achieving occupational standards for personnel within the industrial ecosystem.

Accordingly, this study seeks to address the following research questions:

1. How can a blended learning (BL) model be combined with competency-based learning (CBL) to improve the competencies of welders in Thailand's industrial welding sector in accordance with occupational norms and professional qualifications?

2. To what extent does the BL integrated with the CBL model help to improve welder competencies in accordance with occupational requirements and professional qualifications?

Given these challenges, this research aims to develop a BL model integrated with competency-based learning to enhance welders' competencies in accordance with occupational standards and professional qualifications in Thailand's industrial welding sector. This initiative supports welders in achieving higher professional standards, meeting industry demand, and ultimately contributing to the growth of the national economy and enhancing Thailand's global competitiveness.

2. Literature Review

2.1. Blended Learning (BL)

Blended Learning (BL) is defined as a teaching approach that combines face-to-face instruction with online learning to maximize learning effectiveness (Graham & Dziuban, 2008). This approach allows learners flexible access to materials, opportunities for repeated practice, and continuous feedback. Furthermore, it enables instructors to adapt teaching methods to suit diverse learners while ensuring alignment with competency standards. Heibel, Anderson, and Drewery (2021) highlighted the integration of Virtual Reality (VR) into welding training as part of BL. VR enhances the efficiency of hands-on training, mitigates safety concerns, and provides opportunities for repeated practice. Similarly, Ahmed, Alwi, and Akhtar (2022) reviewed the application of Competency-Based Education (CBE) through BL in Pakistan's TVET (Technical and Vocational Education and Training) system, demonstrating its flexibility and alignment with labor market demands. Hashim and Hamidon (2022) further emphasized the benefits of BL in vocational training, integrating classroom workshops, online platforms such as Google Classroom, and on-the-job training. Their findings confirm that BL improves technical learning experiences and outcomes. In addition, Hu, Chang, and Ho (2024) compared blended, face-to-face, and online training methods for teaching functional skills in vocational education, reporting that BL yielded the highest overall performance and learner satisfaction.

2.2. Competency-Based Learning (CBL)

Competency-Based Learning (CBL) emphasizes demonstrable learning outcomes rather than time spent on instruction. Learners are required to achieve specified competencies across three dimensions: knowledge, skills, and attitudes. Assessments rely on evidence of actual performance, such as performance tests, projects, work samples, or competency-based assessments (Alharbi, 2024; Cano García & Lluch Molins, 2022). CBL is characterized by flexibility, opportunities for repetition, and continuous feedback until mastery is achieved. Occupational standards and professional qualifications often serve as benchmarks to ensure that acquired competencies align with recognized industry requirements. Wibowo, Kuat, and Sayuti (2022) demonstrated that integrating adaptive and productive curricula enhances job-related competencies among learners. In Indonesia, Muslim et al. (2024) reported that competency-based training in industrial engineering, such as energy-efficient vehicle design, improved learner readiness for competitions and industry practice. Similarly, Marwanto et al. (2024) found that competency-based training in Non-Destructive Testing (NDT) enhanced vocational instructors' abilities to teach welding assessments, thereby improving student outcomes.

Skill acquisition frameworks further reinforce the application of CBL. Chanrueang and Pitukkitwattana (2021) demonstrated that applying De Cecco's principles significantly improved learning outcomes in skill-based courses. Salehi, Tahmasebi, and Talebrokni (2021) compared motor learning models and found that Fitts and Posner's (1967) three-stage model enabled trainers to identify learners' stages and tailor instruction accordingly. Collectively, these findings underscore the

potential of CBL for advancing welding competencies, though successful implementation requires adequate instructor preparation, curriculum design, and assessment methods.

2.3. Occupational Standards and Professional Qualifications for Welding Workforce

Occupational Standards and Professional Qualifications are essential tools for welding workforce development, especially given the rapid pace of technological change and labor market demands. Clear, internationally recognized standards ensure consistency in training and assessment (AWS, 2025; CSA, 2025). Global benchmarks such as AWS D1.1, ASME Section IX, and ISO 9606 are widely recognized, providing structured frameworks for training and certification. For example, ISO 9606 specifies welder qualification levels (1G, 3G, 6G) aligned with industry needs (European Welding Federation & IIW, 2025). CSA W47.1-2025 in Canada defines certification requirements for companies engaged in steel welding, ensuring credibility and quality. Programs such as TWI South East Asia's "Welding Zero to Hero" exemplify the use of international standards for training and certification, thereby enhancing employment prospects for welders. Klomim and Kuayngern (2025) further reported that aligning training with global standards significantly improved both theoretical knowledge and practical skills among learners. Despite these benefits, challenges remain, including limited institutional resources and the need to update curricula to align with industry requirements and global standards (AWS, 2025). Thus, integrating professional standards into training and assessment is indispensable for preparing welders to meet labor market demands, increasing employability, and advancing careers (AWS, 2025; CSA, 2025).

A review of existing studies reveals a gap: no prior research has integrated BL and CBL in welding training to directly assess the effectiveness of competency development aligned with occupational standards and professional qualifications. This research seeks to fill this gap by developing and evaluating a PRO-WELD Model tailored for Thailand's industrial welding sector, contributing to global best practices in welding education and workforce development.

3. Methodology

3.1. Research Objectives

1. To develop a BL integrated with the CBL model to enhance the competencies of welders in Thailand's industrial welding sector in alignment with occupational standards and professional qualifications.
2. To examine the effectiveness of the BL integrated with the CBL model in developing welders' competencies in accordance with occupational standards and professional qualifications.

3.2. Research Framework

This research integrates key concepts of blended learning, competency-based learning, and occupational standards and professional qualifications in the Industrial Welding Profession: Shielded Metal Arc Welder, Level 2. The central variable is the PRO-WELD Model (Professional Welding Education through Learning & Development aligned with standards), which serves as the framework for developing and evaluating learning outcomes. The research framework is illustrated in Figure 1.

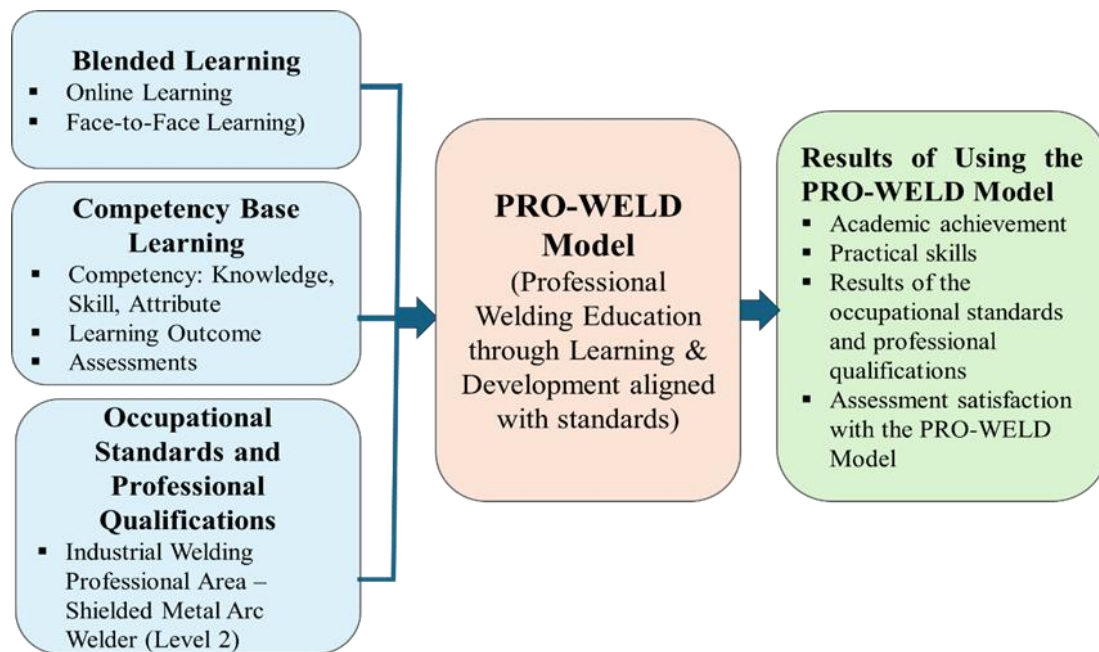


Figure 1. Research Framework

3.3. Research Methodology

This study adopted a Research and Development (R&D) design and employed a mixed-methods approach integrating quantitative and qualitative techniques to obtain comprehensive and in-depth evidence. The research was conducted in two phases as follows.

Phase 1: Development of a BL integrated with the CBL model to enhance welders' competencies in accordance with the occupational standards and professional qualifications of Thailand's industrial welding sector

1. Research Stage (R1)

This stage involved studying and analyzing information to develop a BL integrated with the CBL model to upgrade welders' competencies in line with occupational standards and professional qualifications in Thailand's industrial welding profession. The details are as follows.

1.1. Documentary sources for synthesis

Peer-reviewed documents and research articles indexed in international databases (e.g., Scopus, Web of Science) concerning: BL, CBL, occupational standards, and professional qualifications for the industrial welding profession; industrial welding; steel materials; and Shielded Metal Arc Welder (Level 2).

1.2. Variables

Independent variables: Foundational information on BL, CBL, and occupational standards and professional qualifications in the industrial welding profession.

Dependent variable: The BL integrated with the CBL model to develop welders' competencies in accordance with Thailand's occupational standards and professional qualifications in the industrial welding profession.

1.3. Target groups

1.3.1. Experts tasked with evaluating the learning model: five evaluators who are faculty members or academics holding a doctoral degree or higher, with at least five years of professional experience and research publications in related areas.

1.3.2. Sample for needs assessment: sixty welders employed in industrial establishments (three per establishment from 20 establishments), each having completed at least upper secondary education (or equivalent), with no more than five years of welding experience, aged not more than 30 years, and without a National Skill Standard certificate in the Shielded Metal Arc Welding (Level 1). A purposive sampling technique was used.

1.4. Research instruments

1.4.1. A structured questionnaire comprising three sections: Section 1—respondent demographics; Section 2—welders' learning needs; Section 3—open-ended suggestions regarding desired content, format, or learning methods.

1.4.2. The prototype BL and CBL model for developing welders' competencies in accordance with occupational standards and professional qualifications in Thailand's industrial welding profession.

1.5. Data analysis

1.5.1. Documentary analysis of theories, principles, and concepts related to BL, CBL, and occupational standards and professional qualifications in the industrial welding profession using content analysis.

1.5.2. Analysis of the structured questionnaire: Section 1 (demographics): descriptive statistics (frequency and percentage) to describe the sample. Section 2 (learning needs): a five-point Likert-type rating scale; analysis using mean and standard deviation, with ranking of needs from highest to lowest to inform model development aligned with welders' requirements. Section 3 (open-ended items): content analysis to code responses, categorize them by emergent issues, and synthesize into key themes reflecting respondents' views, expectations, and recommendations regarding content, duration, teaching methods, and anticipated learning outcomes.

2. Development Stage (D1)

This stage involved designing, developing, and establishing the quality of (i) the learning model, (ii) the supporting instruments for implementing the model, and (iii) the instruments for evaluating the model's effectiveness, as follows.

2.1. Research instruments

2.1.1. The BL and CBL models are aligned with occupational standards and professional qualifications in the industrial welding profession for upgrading welders' competencies within Thailand's industrial ecosystem.

2.1.2. A user manual for implementing the BL and CBL model aligned with the standards.

2.1.3. Lesson plans for model implementation.

2.1.4. Effectiveness-evaluation instruments for the model, comprising: (a) an achievement test; (b) a welding performance assessment; and (c) a learner satisfaction questionnaire regarding the model.

2.2. Target groups

2.2.1. Five experts examine the content validity of the effectiveness-evaluation instruments used with the model.

2.2.2. Five experts to validate the BL and CBL model for upgrading welders' competencies; all hold a doctoral degree or higher with at least five years of experience.

2.2.3. Sample for model effectiveness testing: fifteen welders meeting the same inclusion criteria as in Phase 1 (upper secondary education or equivalent; ≤ 5 years' welding experience; age ≤ 30 ; no

prior National Skill Standard certificate in Industrial Mechanic—Shielded Metal Arc Welding Level 1), selected by purposive sampling.

2.3. Research procedures

2.3.1. Model development and suitability appraisal: The model was developed based on BL, CBL, and the occupational standards and professional qualifications for the industrial welding profession—Shielded Metal Arc Welder, Level 2. The draft model's suitability was then appraised using a five-point Likert-scale instrument.

2.3.2. Development and appraisal of implementation tools: The model's user manual and lesson plans were developed and their suitability examined using the same five-point Likert rating scale.

2.3.3. Development and quality assurance of effectiveness-evaluation instruments: The instruments developed and validated for assessing the effectiveness of the learning model included: 1) an achievement test to measure learning outcomes, 2) a practical welding skills assessment form, and 3) a satisfaction questionnaire to evaluate welders' perceptions of the blended and CBL model designed to enhance welding competencies in accordance with the National Occupational Standards and Professional Qualifications in the field of industrial welding in Thailand. The details of these instruments are as follows:

1) Achievement test: constructed to cover all Performance Criteria stipulated in the occupational standards and professional qualifications for the industrial welding profession—Shielded Metal Arc Welder, Level 2. The test comprised 40 multiple-choice items (4 options each). Five experts assessed content validity; Item–Objective Congruence (IOC) indices were calculated, and items with $\text{IOC} \geq 0.50$ were retained. The test was then piloted with five welders, comparable to but distinct from, the research sample, to estimate reliability using Cronbach's alpha.

2) Welding performance assessment: developed in alignment with competency units, sub-competencies, Performance Criteria, and the Assessment Description and Procedure under the national standards, together with ISO 5817 (Welding—Fusion-welded joints in steel, nickel, titanium and their alloys—Quality levels for imperfections; beam welding excluded). The instrument used a rubric-based scoring format with five levels. It comprised five parts: (a) Visual Inspection Test, (b) Fracture Test, (c) Bending Test, (d) Fabrication to drawing/specifications, and (e) Safety and operational capability. Five experts examined content validity, IOC indices were computed (retaining items with $\text{IOC} \geq 0.50$), and the instrument was piloted with five comparable welders to estimate reliability (Cronbach's alpha).

3) Learner satisfaction questionnaire: covered five domains: learner, instructor, content, instructional media, and assessment—rated on a five-point Likert scale. Five experts verified content validity; IOC indices were computed, and items with $\text{IOC} \geq 0.50$ were retained.

2.3.4. Evaluation of model effectiveness: The effectiveness of the blended and CBL model, aligned with the occupational standards and professional qualifications for the industrial welding profession, was evaluated with 15 welders by comparing the percentage of formative assessment scores (E1) with the percentage of post-instruction assessment scores (E2). The predetermined effectiveness criterion was 75/75, meaning that learners should achieve an average formative score ($\text{E1} \geq 75\%$) and an average post-test score ($\text{E2} \geq 75\%$) for the model to be deemed effective. This 75/75 benchmark was set to exceed the minimum national occupational assessment thresholds for Shielded Metal Arc Welder, Level 2 (i.e., theory $\geq 70\%$, practice $\geq 70\%$, and overall average $\geq 70\%$), thereby ensuring that the instructional model not only meets but surpasses the basic standards.

2.4. Data Analysis

2.4.1. Analysis of model- and tool-suitability appraisals: Data from the suitability evaluations of the learning model and its implementation tools (i.e., the model user manual and lesson plans) were analyzed using the mean (M) and standard deviation (SD) of the rated suitability across the model's components and expert judgments. The resulting statistics were then interpreted against predefined criteria.

2.4.2. Quality analysis of the learning achievement test: Test quality was examined for content validity via the Index of Item–Objective Congruence (IOC) and for reliability via Cronbach's alpha. The learning achievement test yielded an IOC of 0.95 and an α of 0.87, indicating high reliability.

2.4.3. Quality analysis of the welding performance assessment: The performance assessment was evaluated for content validity (IOC) and reliability (Cronbach's alpha). Results showed IOC = 0.96 and α = 0.92, indicating very high reliability.

2.4.4. Analysis of the welder satisfaction questionnaire: Satisfaction data affecting the use of the learning model were analyzed using M and SD. The content validity assessment yielded an IOC of 1.00, confirming excellent congruence between the items and the intended constructs.

2.4.5. Analysis of instructional model effectiveness (E1/E2): Model effectiveness was assessed using the E1/E2 criterion. E1 represents the instructional process efficiency, computed from the average scores on in-course exercises/activities; E2 represents post-instruction achievement, computed from the average post-test score. The effectiveness index E1/E2 was compared against the benchmark 75/75, which requires $E1 \geq 75\%$ and $E2 \geq 75\%$. Meeting or exceeding 75/75 indicates that the developed instructional model is effective as specified. Notably, this benchmark was set above the minimum thresholds of the national occupational assessment for Shielded Metal Arc Welder, Level 2 (theory $\geq 70\%$, practice $\geq 70\%$, and overall average $\geq 70\%$), thereby ensuring performance that surpasses baseline standards.

Phase 2: Evaluation of the Effectiveness of the BL and CBL Model for Developing Welders' Competencies in Accordance with Thailand's Occupational Standards and Professional Qualifications (Industrial Welding Profession)

This phase examined the effectiveness of the learning model in practice. Findings from the effectiveness evaluation were analyzed to refine and improve the model. The study comprised two steps:

1. Step 1: Research (R2)

This step piloted the learning model in an authentic training context using the lesson plans designed according to the prescribed instructional sequence. During implementation, formative evaluation of instructional delivery was conducted, welders' competencies were assessed, and post-implementation satisfaction was surveyed. The resulting data were then analyzed. Details are as follows:

1.1. Sample

The sample consisted of 20 welders employed in industrial establishments who had completed at least upper secondary education or vocational certificate (or equivalent), had no more than two years of welding work experience, and had not obtained the National Skill Standard certificate in the Industrial Mechanic—Shielded Metal Arc Welding (Level 1).

1.2. Research instruments

1.2.1. The blended and CBL model aligned with national occupational standards and professional qualifications for Thailand's industrial welding profession.

1.2.2. The model user manual.

1.2.3. Lesson plans aligned with the occupational standards and professional qualifications—Shielded Metal Arc Welder, Level 2.

1.2.4. Effectiveness-evaluation instruments: (a) a learning achievement test, (b) a welding performance assessment, and (c) a welder satisfaction questionnaire on the BL and CBL model.

1.3. Experimental procedures: Implementation comprised three stages:

1.3.1. Pre-implementation preparation.

The researcher briefed the 20-welder sample on the purpose of the model-based instruction, the nature of the learning activities, learner roles, information resources, the use of instructional media, and the assessment criteria so that trainees clearly understood the competency evaluation standards.

1.3.2. Implementation of the model.

The researcher delivered instruction using the learning model, user manual, and lesson plans developed for the study. Details include:

1) Experimental design: The research design was aligned with the study's objectives to both develop and determine the effectiveness of the instructional model. Specific objectives were articulated to delimit scope and ensure coherence with the research questions, hypotheses, methods, and data analysis plan. The details of the experimental design are as follows:

Table 1 Methodological Design

Specific Objective	Experimental Design	Symbolic Representation	Statistical Analysis	Hypotheses
To compare learning achievement in welding steel using shield metal arc welding (SMAW) before and after the learning model intervention.	The One-Group Pretest–Posttest Design	$O_1 \rightarrow X \rightarrow O_2$ $O_1 = \text{Pretest}$ $X = \text{Learning Model}$ $O_2 = \text{Posttest}$	Paired Sample t-test	$H_0: \mu_{\text{difference}} = 0$ $H_1: \mu_{\text{difference}} \neq 0$
To compare welding skills after the intervention against a predetermined criterion (75%).	One-Group Posttest-Only Design with Criterion Comparison	$X \rightarrow O_1$ $X = \text{Learning Model}$ $O_1 = \text{Posttest compared with criterion (75\%)}$	One-Sample t-test	$H_0: \mu = 75$ $H_1: \mu \neq 75$

Specific Objective	Experimental Design	Symbolic Representation	Statistical Analysis	Hypotheses
To compare welding competency after learning with the model against professional and occupational qualification standards.	The One-Group Repeated Measures Design	$O_1 \rightarrow O_2$ O_1 = Posttest after learning model O_2 = Posttest after 1 week (professional standards)	Paired Sample t-test	$H_0: \mu_{\text{difference}} = 0$ $H_1: \mu_{\text{difference}} \neq 0$
To study welders' satisfaction with the developed learning model.	One-Group Posttest-Only Design	$X \rightarrow O$ X = Learning Model O = Satisfaction assessment	Mean (M) and Standard Deviation (SD)	Interpretation against predetermined criteria

2) Implementation of the Learning Model: The learning model was implemented according to the user manual and the developed lesson plans, with a total instructional time of 24 hours, allocated as follows:

1. E-learning (6 hours):

Module 1: Safety, Occupational Health, and Environmental Considerations in Welding

Module 2: Welding of Steel

2. Onsite (Face-to-Face) Learning (12 hours):

Practical welding exercises covering two workpieces: Workpiece 1: T-joint, fillet weld, vertical-up position (ISO 6947 FW PF, AWS 3F); duration: 6 hours. Workpiece 2: Butt joint with single-sided V-groove, flat position (ISO 6947 BW PA, AWS 1G); duration: 6 hours

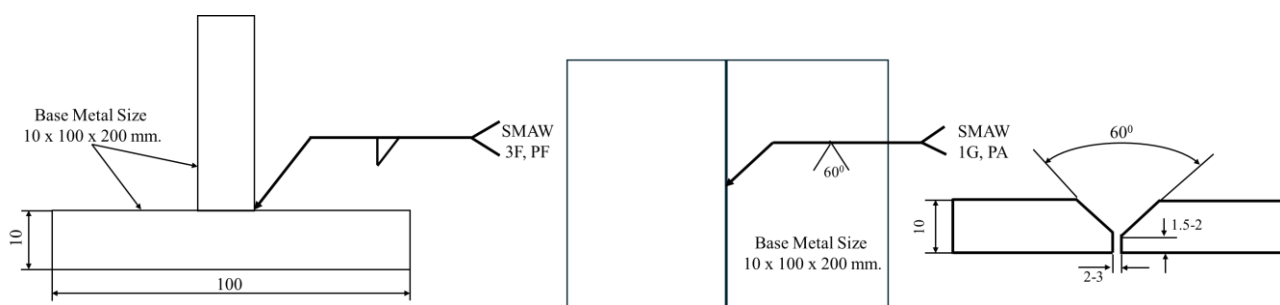


Figure 2. Welding Workpieces: T-joint with Fillet Weld in Vertical-Up Position (3F, PF) and Single-Sided V-Groove Butt Joint in Flat Position (1G, PA).

3. Assessment (6 hours)

The assessment comprised 6 hours, divided as follows:

3.1. Assessment of welding competencies in steel using the shield metal arc welding (SMAW) process (2 hours), including: Learning achievement test: 40 multiple-choice questions, administered before and after the learning model intervention. Practical welding skill assessment: two workpieces

— (1) T-joint with fillet weld in vertical-up position, and (2) single-sided V-groove butt joint in flat position. Both were evaluated after the learning model was completed.

3.2. Competency assessment in accordance with occupational standards and professional qualifications for the Industrial Welding Profession—Shield Metal Arc Welding, Level 2. The assessment was conducted by the Professional Qualification Institute (Public Organization) as an accredited body, covering both theoretical and practical components (4 hours).

3.3. Assessment of welders' satisfaction with the instructional model.

1.3.3. Effectiveness Evaluation of the Learning Model: Data was collected from: (a) The competency assessment of steel welding using SMAW, (b) The competency assessment based on occupational standards and professional qualifications for SMAW, Level 2, and (c) The welder satisfaction survey. All data were subsequently analyzed to test the research hypotheses statistically.

1.3.4. Data Analysis: The analysis was conducted as follows:

1) Comparison of learning achievement in SMAW: Dependent t-test.

2) Analysis of welding skill performance: calculation of Mean ($\bar{X}$) and Standard Deviation (SD), compared against the criterion of 75%.

3) Analysis of competency assessments against occupational standards (SMAW Level 2): M and SD, compared to the passing standard of 70%.

4) Analysis of welder satisfaction with the learning model: $\bar{X}$ and SD, compared against the benchmark criterion of "high satisfaction."

2. Step 2: Development (D2)

This phase involved refining the learning model. The process entailed reviewing and improving the model based on the competency assessment results and welders' satisfaction data. The goal was to enhance the effectiveness of the instructional process.

2.1. Research Instrument:

The BL and CBL model aligned with occupational standards and professional qualifications for welders in Thailand's industrial ecosystem.

2.2. Data Collection:

The model was revised to ensure appropriateness across all components based on evaluation results and subsequently finalized as the completed instructional model.

2.3. Data Analysis:

Data from the evaluation of the BL and CBL model were analyzed using Content Analysis.

4. Results

4.1. Development of the BL and CBL Model for Welding Competencies

The findings from studying and analyzing BL approaches for adult learners and welders indicated that BL is flexible, accessible, and suitable for working learners, who often balance employment and family responsibilities. BL allows learning anytime, anywhere through online modules, while also integrating hands-on practice sessions. Engagement can be increased through case studies, simulations, and scenario-based eLearning, which enhance learners' motivation and connect knowledge to real-world applications. Moreover, self-directed learning and student-centered approaches foster independent learning and collaborative opportunities. The essential components of effective BL for working learners include: 1) Online learning, 2) Face-to-face learning, 3)

Instructional design, 4) Learning materials and media, 5) Assessment and feedback, and 6) Learner engagement.

The analysis of CBL for working learners further revealed that CBL emphasizes outcomes in real work performance, focusing on competencies that can be directly applied in practice. This approach is particularly relevant for vocational learners or workers seeking to upgrade their skills and achieve sustainable competitiveness in the labor market. Key elements of CBL include 1. Defined competency standards, 2) Clear learning outcomes, 3) Flexible and individualized learning, 4) Performance-based assessment, and 5) The instructor’s role as a coach. Additionally, an in-depth analysis of occupational standards and professional qualifications for the Industrial Welding Profession—Shield Metal Arc Welding, Level 2 was conducted. The results were translated into a detailed instructional plan, transforming occupational standards into comprehensive lesson plans, as presented in Table 2.

Table 2. Translation of Occupational Standards into Comprehensive Learning Plan Specifications

Occupational Standards	Learning Plan
1. Name of Occupation	1. Title of Competency-Based Curriculum
2. Characteristics of Outcomes	2. Curriculum Objectives
3. Unit of Competency	3. Title of Learning Unit
4. Element of Competency	4. Title of Sub-Learning Unit
	5. Behavioral Objectives
5. Performance Criteria	6. Assessment Criteria
6. Description of Unit of Competency	7. Course Description
7. Assessment of Occupational Standards	8. Assessment Methods
8. Required Skills and Knowledge	9. Learning Management Methods
	10. Learning Activities
9. Range Statement	11. Content Details

Data on training needs were collected from 60 welders employed in industrial establishments using a structured questionnaire. The analysis results are as follows:

Part 1: General Information of Respondents

The demographic data were analyzed using frequency and percentage, with the following results:

Gender: Male, 56 respondents (93.33%); Female, 4 respondents (6.66%).

Age: 18–21 years, 22 respondents (36.66%); 22–24 years, 28 respondents (46.66%); 25–27 years, 10 respondents (20.00%); 28–30 years, 4 respondents (6.66%).

Education Level: Upper secondary education or equivalent, 45 respondents (75.00%); Higher vocational certificate or equivalent, 15 respondents (25.00%).

Work Experience: 1–2 years, 32 respondents (53.33%); 3–5 years, 14 respondents (23.33%).

Part 2: Learning Needs of Welders

The learning needs were assessed using a 5-point Likert scale. Data were analyzed with descriptive statistics, specifically mean ($\bar{X}$) and standard deviation (SD). The results are presented in Table 3.

Table 3. Analysis of Welders' Learning Needs According to Occupational Standards and Professional Qualifications in Industrial Welding, Shielded Metal Arc Welding (Level 2).

Items	$\bar{X}$	SD	Level of Demand
Competencies in Welding according to Occupational and Professional Standards			
1. Safety, Occupational Health, and Welding Environment	4.84	0.89	Highest Demand
2. Steel Welding	4.86	0.43	Highest Demand
3. Preparation for Shield Metal Arc Welding according to Fillet Weld and Groove Weld Specifications	4.81	0.97	Highest Demand
4. Performing Shield Metal Arc Welding according to Fillet Weld and Groove Weld Specifications	4.95	0.44	Highest Demand
5. Inspection of Shield Metal Arc Welding Quality according to Fillet Weld and Groove Weld Specifications	4.90	0.88	Highest Demand
Preferred Learning Modes			
1. Online Video-Based Learning	4.67	0.75	Highest Demand
2. E-Learning (Online System)	4.90	0.54	Highest Demand
3. Practical Welding Training in Enterprises/Training Centers	4.97	0.61	Highest Demand
4. Learning through Welding Demonstrations by Instructors/Trainers	4.83	0.98	Highest Demand
5. Learning through Simulations	4.23	0.75	High Demand
6. Project-Based Learning	4.04	0.68	High Demand
7. Peer Learning with Colleagues	4.12	0.59	High Demand

From Table 3, the analysis of welders' learning needs based on occupational standards and professional qualifications in industrial welding, Shielded Metal Arc Welder (Level 2), revealed that welders expressed the highest level of learning needs across all items. Specifically, SMAW tasks performed according to work orders for fillet and groove welds showed the highest demand ($\bar{X}$ = 4.95, SD = 0.44). Regarding preferred learning modalities, welders indicated the strongest preference for

BL, combining online instruction with face-to-face training. In particular, hands-on welding practice conducted at industrial establishments or training centers was rated as the most highly desired ($\bar{X} = 4.95$, $SD = 0.44$).

Part 3 consisted of open-ended questions soliciting additional suggestions regarding content, formats, or instructional methods. Welders provided feedback such as:

“Theoretical content should be presented in clear, simple, and practical language.”

“Online lessons should be user-friendly and allow for easy review.”

“Practical training should incorporate real-world case studies.”

“Weld quality inspection should include explanations of causes and corrective methods.”

“Completion of the training should allow direct assessment for certification in line with occupational standards and professional qualifications.”

These suggestions were considered in refining the learning model. Based on the study finding analysis of BL approaches, CBL, occupational standards and professional qualifications for industrial welding, Shielded Metal Arc Welder Level 2, and the survey of welders’ skill development needs—the BL and CBL Model for Developing Welders’ Competencies was developed. The quality of the proposed model framework, along with its supporting tools (i.e., the model user manual and instructional plans), was subsequently evaluated for suitability. The results of this evaluation are presented in Table 4.

Table 4. Expert Evaluation of the Suitability of the BL and CBL Model for Developing Welders’ Competencies in Accordance with Occupational Standards and Professional Qualifications in Thailand’s Industrial Welding Profession.

Evaluation Items	$\bar{X}$	SD	Appropriateness Level
1. Components of the Learning Model	4.70	0.50	Highly Appropriate
2. Principles of the Learning Model	4.60	0.55	Highly Appropriate
3. Objectives of the Learning Model	4.80	0.45	Highly Appropriate
4. Learning Process	4.70	0.50	Highly Appropriate
5. Learning Media	4.60	0.55	Highly Appropriate
6. Assessment and Certification of Qualifications according to Occupational and Professional Standards	4.80	0.45	Highly Appropriate
7. Roles of Instructors and Learners	4.40	0.55	Appropriate
8. Diagram of Learning Model Components	4.80	0.45	Highly Appropriate
Overall Mean	4.67	0.50	Highly Appropriate

From Table 4, the evaluation of the learning model's suitability by five experts, who assessed eight dimensions comprising 24 items, revealed that the overall suitability was rated at the highest level ($\bar{X} = 4.67$, $SD = 0.50$). Specifically, the following dimensions were rated at the highest level of suitability: objectives of the learning model, assessment and certification in accordance with occupational standards and professional qualifications, diagrammatic representation of the model's components, model components, instructional procedures, principles of the learning model, and

instructional media. Meanwhile, the roles of instructors and learners were rated at a very high level of suitability.

Table 5. Results of the Quality Evaluation of the Learning Model User Manual

Evaluation Items	$\bar{X}$	SD	Appropriateness Level
1. Content and Structure of the Manual	4.80	0.45	Highly Appropriate
2. Guidelines for Learning Management	4.40	0.55	Appropriate
3. Utilization of Technology and Learning Media	4.80	0.45	Highly Appropriate
4. Clarity and Practical Application	4.60	0.55	Highly Appropriate
Overall Mean	4.65	0.50	Highly Appropriate

The user manual of the learning model was evaluated across four dimensions with 20 assessment items by experts. From Table 5, the findings indicated that the manual was rated at the highest level of quality and suitability ($\bar{X} = 4.67$, $SD = 0.50$). Specifically, the dimensions of content and structure of the manual, use of technology and instructional media, and clarity and practical applicability were rated at the highest level of suitability, while the dimension of guidelines for instructional management was rated at a very high level of suitability.

Table 6. Results of the Quality Evaluation of the Learning Management Plan

Evaluation Items	$\bar{X}$	SD	Appropriateness Level
1. Core Content (Big Idea / Core Content)	4.60	0.55	Highly Appropriate
2. Learning Objectives	4.80	0.45	Highly Appropriate
3. Content	4.80	0.45	Highly Appropriate
4. Learning Process	4.80	0.45	Highly Appropriate
5. Media / Innovation / Learning Resources	4.60	0.55	Highly Appropriate
6. Assessment and Evaluation	4.80	0.45	Highly Appropriate
7. Feasibility of Practical Application	4.60	0.55	Highly Appropriate
Overall Mean	4.71	0.50	Highly Appropriate

The lesson plans were evaluated for quality and suitability across seven dimensions with 21 assessment items by experts. The evaluation results, presented in Table 6, indicated that the lesson plans achieved the highest level of quality and suitability ($\bar{X} = 4.71$, $SD = 0.50$). Specifically, the dimensions of learning objectives, content, learning processes, assessment and evaluation, core content (Big Idea/Core Content), instructional media/innovation/learning resources, and practical feasibility were all rated at the highest level of quality and suitability. Therefore, the developed lesson plans were deemed highly appropriate for use in instructional management under the proposed learning model to enhance welders' competencies.

Table 7. Results of the Effectiveness Evaluation of the BL and CBL Model for Developing Welders' Competencies in Accordance with Occupational Standards and Professional Qualifications in Thailand's Industrial Welding Profession.

Experimental Group Using the Learning Model	Full Score	$\bar{X}$	SD	Percentage
Scores During Learning (E1)	100	78.35	0.87	78.35
Scores After Learning (E2)	100	77.45	0.91	77.45

From Table 7, the results of the effectiveness evaluation of the learning model with an experimental group of 15 welders were obtained by comparing the percentage scores during training (E1) with the percentage scores after training (E2) in order to determine whether the instructional model met the established effectiveness criterion of 75/75. The results indicated that the E1/E2 values were 78.35/77.45, which exceeded the minimum criterion of 70/70. Therefore, it can be concluded that the Blended and CBL Model for Developing Welders' Competencies in Accordance with Occupational Standards and Professional Qualifications in Thailand's Industrial Welding Profession achieved the required level of effectiveness.

Based on the results of the suitability evaluation of the learning model, the assessment of the user manual and lesson plans, as well as the pilot implementation of the learning model, the researcher compiled recommendations from experts and feedback from the trial implementation to refine and improve the model. The finalized learning model was designated as the "PRO-WELD Model (Professional Welding Education through Learning & Development aligned with standards)", as illustrated in Figure 3.

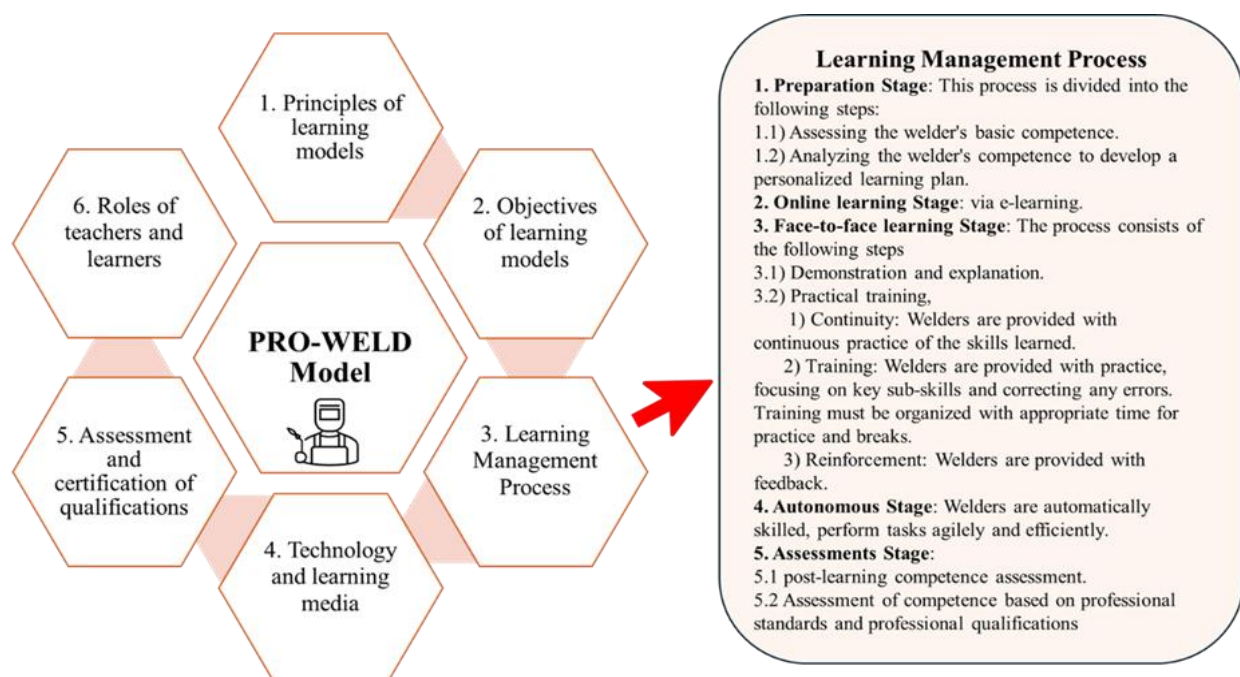


Figure 3. PRO-WELD Model

From Figure 3, the components of the PRO-WELD Model consist of six elements: 1) Principles of the Learning Model, 2) Objectives of the Learning Model, 3) Learning Procedures, 4) Technology and Learning Media, 5) Assessment and Certification in Accordance with Occupational Standards and Professional Qualifications and 6) Roles of Instructors and Learners

The details of these components are as follows:

1. Principles of the Learning Model

The development of personnel in Thailand's welding industry—particularly welders—requires an effective learning model aligned with the demands of the modern labor market. Such a model must ensure that learners achieve competencies consistent with occupational standards and professional qualifications, enabling them to perform effectively in real industrial contexts. The BL approach, combined with CBL, provides a foundation for comprehensive learner development across knowledge, skills, and attributes. The principles of this learning model are:

1) Competency-Oriented: The model is anchored in industrial welding competency standards, ensuring that instructional activities are designed to achieve outcomes where learners can perform tasks as specified in the standards.

2) BL Approach: Integration of self-paced online learning, face-to-face instruction, and practical welding training enables learners to access diverse content and practice real-world skills effectively, offering flexibility particularly suitable for working learners.

3) Competency-Based Assessment: Assessment is grounded in actual performance, employing a variety of tools to ensure learners meet the required competency benchmarks.

4) Qualification Pathway: The blended and competency-based model is linked to the national qualification certification process, allowing learners to undergo competency assessments and obtain certification from accredited bodies under the Professional Qualification Institute (Public Organization). This enhances employment opportunities and career progression.

2. Objectives of the Learning Model

1) To develop welders' competencies in knowledge, skills, and attributes in accordance with occupational standards and professional qualifications in Thailand's industrial welding profession, emphasizing practical learning supported by technology-enhanced instruction.

2) To promote flexible, contextualized learning for working learners through BL that integrates online study with hands-on practice, enabling direct application of competencies in real-world situations.

3. Learning Procedures

The instructional procedures integrate BL, competency-based learning, and skill acquisition theories from De Cecco (1974) and Fitts & Posner (1967). The stages are:

1. Preparation:

1.1) Initial competency assessment of welders through self-assessment and pretests to establish baseline competencies relative to occupational standards.

1.2) Competency analysis to create personalized learning plans (Personalized Learning). Learners lacking prerequisite skills receive supplementary training to ensure readiness.

2. Online Learning (6 hours): Module 1: Safety, Occupational Health, and Environment in Welding and Module 2: Welding of Steel

3. Face-to-Face Learning (12 hours): Practical welding tasks: Workpiece 1: T-joint, fillet weld, vertical-up position (ISO 6947 FW PF, AWS 3F), 6 hours and Workpiece 2: Single-sided V-groove butt joint, flat position (ISO 6947 BW PA, AWS 1G), 6 hours

Steps include:

3.1) Demonstration and Explanation: Instructors demonstrate sequential welding operations from simple to complex, highlighting key details. Learners with insufficient prior skills receive additional foundational training.

3.2) Hands-on Practice: Guided by principles of:

1) Continuity — practicing sequentially without interruption.

2) Practice and Correction — focusing on critical sub-skills, correcting errors, and balancing practice/rest periods.

3) Reinforcement (Feedback): 1) Extrinsic Feedback — instructor comments on performance strengths and weaknesses. 2) Intrinsic Feedback — self-observation by learners as they gain proficiency.

4. Autonomous Stage: Learners perform tasks automatically and efficiently. Instructors encourage self-evaluation against welding criteria, guiding learners to independently correct errors.

5. Evaluation:

5.1. Post-learning competency assessment based on the model.

5.2. Assessment aligned with occupational standards and professional qualifications in industrial welding, Shielded Metal Arc Welder Level 2.

4. Learning Media and Resources

4.1. E-learning modules

4.2. Practical welding workpieces

4.3. Learning achievement tests

4.3. Welding performance assessment tools

4.5. Supplementary learning documents

4.6. User manual of the learning model

4.7. Lesson plans

5. Assessment and Certification in Accordance with Occupational Standards and Professional Qualifications

5.1. Learning achievement test

5.2. Welding performance assessment

5.3. Competency assessment of welders according to occupational standards and professional qualifications in industrial welding, Shielded Metal Arc Welder Level 2, conducted by accredited bodies under the Thailand Professional Qualification Institute (Public Organization).

6. Roles of Instructors and Learners

6.1. Instructors

1) Serve as facilitators/coaches, encouraging learners to discover and develop their competencies independently, while providing guidance, advice, and continuous monitoring of the learning process.

2) Promote experiential learning by enabling learners to gain direct hands-on welding experience and engage in reflective practice.

3) Act as competency assessors, utilizing assessment tools aligned with occupational standards to evaluate learners' actual performance (performance-based assessment) and provide individualized feedback for further development.

6.2. Learners

1) Independently access online lessons and employ technology to further explore welding-related knowledge.

2) Demonstrate responsibility for time management and mastery of content delivered through online learning.

3) Engage in welding practice to meet the specified welding criteria.

4) Evaluate their own performance against established welding standards.

5) Correct errors from welding practice and continuously develop their skills.

4.2. Results of the Implementation of the PRO-WELD Model

The study of the effectiveness of the PRO-WELD Model involved a comparison of learning outcomes in steel welding through SMAW, the examination of welding skill development, the assessment of competencies based on occupational standards and professional qualifications in industrial welding, and the evaluation of welders' satisfaction with the instructional model. The experiment was conducted with a sample group of 20 welders employed in industrial enterprises, with a total learning intervention period of 24 hours. The research findings are presented as follows:

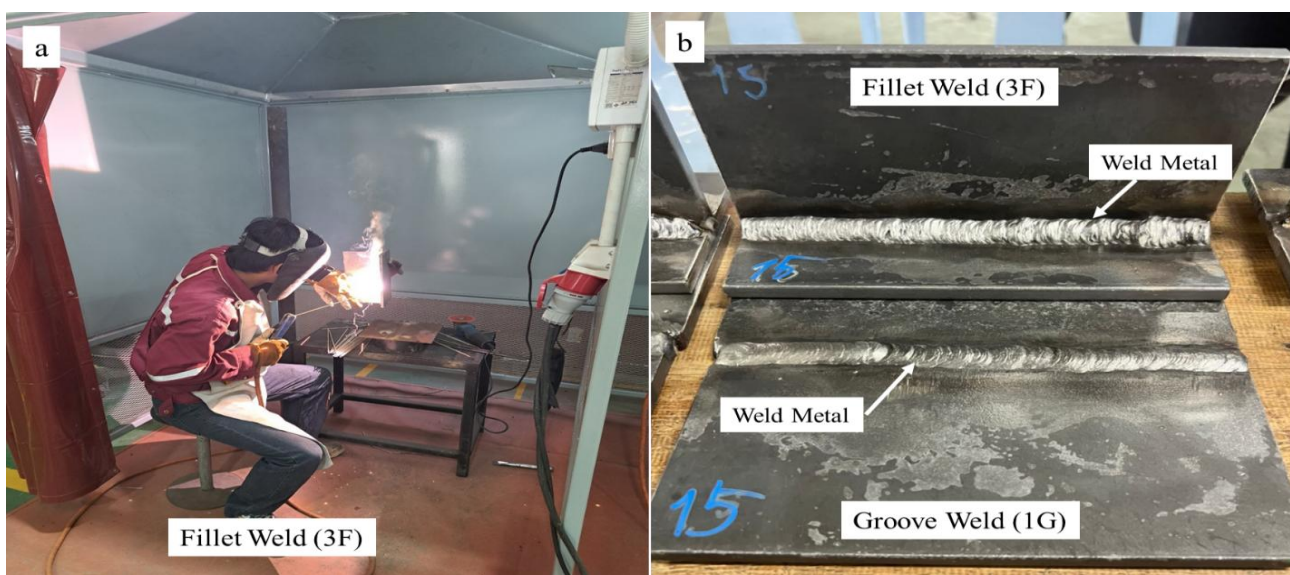


Figure 3. Examination of the Implementation of the PRO-WELD Model a. Welding Practice of Fillet Welds (3F) b. Welded Workpiece Assessed Against Occupational Standards for Welders

Table 8. Comparison of Learning Achievement Scores in Steel Welding through the Shielded Metal Arc Welding (SMAW) Process between Pre-test and Post-test

Test	N	Mean	SD	SE Mean	T-Value	P-Value
Pre-Test	20	19.450	3.086	0.690	-13.16	0.00
Post-Test		30.700	2.105	0.471		

The results of the comparison of learning achievement in steel welding through the SMAW process using the PRO-WELD Model between pre-test and post-test, as shown in Table 8, indicated that the learning achievement scores differed significantly at the 0.05 level ($p < 0.05$). This finding is consistent with the hypothesis H_1 : $\mu \text{ difference} \neq 0$, confirming that the learning achievement in steel welding through the SMAW process significantly improved after the implementation of the learning model. Therefore, it can be concluded that the PRO-WELD Model effectively enhanced the learning achievement of welders in steel welding using the SMAW process. To better understand the extent of this improvement, the effect size was computed using Cohen's d , which estimates the strength of the observed effect. The calculated Cohen's d was 2.94, indicating an astronomical impact size based on Cohen's (1988) criterion ($d = 0.2$ small, 0.5 medium, 0.8 big). This finding implies that the difference between pre-test and post-test learning achievement scores was not only statistically significant, but also educationally significant, showing a noteworthy improvement in welders' learning outcomes. In practice, the huge effect size indicates that the PRO-WELD Model had a significant impact on the mastery of welding knowledge and abilities in the SMAW process. This means that incorporating blended learning with competency-based learning components into the PRO-WELD Model greatly improved welders' understanding, knowledge retention, and performance.

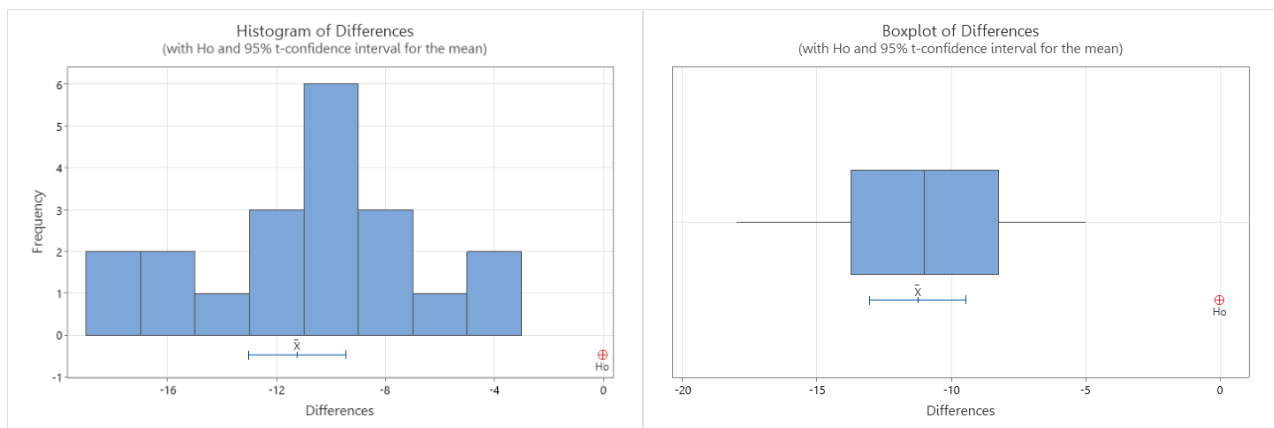


Figure 4. Histogram and Boxplot of Differences in Learning Achievement Scores for Steel Welding through the SMAW Process using the PRO-WELD Model between Pre-test and Post-test

From Figure 4, the histogram and boxplot of the score differences between pre-test and post-test clearly illustrate that post-test scores were consistently higher than pre-test scores. The distribution of the differences aligns with the research hypothesis, indicating that welders demonstrated significant and consistent improvement in learning achievement for manual steel welding. This finding is consistent with the statistical analysis, which confirmed that the difference was statistically significant at the .05 level.

Table 9. Results of the Comparison of Post-test Welding Skill Performance with the Specified Criterion after the Implementation of the Learning Model

N	Mean	S.D.	SE. Mean	T-Value	P-Value
20	78.850	3.573	0.799	4.82	0.00

The researcher collected welders' skill scores after the implementation of the PRO-WELD Model using the following skill assessment criteria: 1. Visual Testing, 2. Fracture Testing (3F) 3. Bending Testing (1G), 4. Assembly According to Prints and Specifications and 5. Safety and Competency Interpretation. The obtained scores were then compared against the specified criterion (75%). From Table 9, the results revealed that the welders' post-test skill performance in steel welding through the SMAW process significantly differed from the criterion, with statistical significance at the 0.05 level (p

< 0.05). This finding is consistent with the hypothesis $H_1: \mu \neq 75$, confirming that learning achievement in SMAW significantly improved after the application of the learning model.

In addition, the effect size (Cohen's d) was calculated to estimate the magnitude of the difference between the sample mean and the criterion. The obtained $d = 1.08$ suggested a large effect size based on Cohen's (1988) benchmark (0.2 = small, 0.5 = medium, 0.8 = large). This finding indicates that the PRO-WELD Model has a significant practical influence on enhancing welder skill performance beyond statistical significance. In practical terms, the average post-test score (mean = 78.85, S.D. = 3.57) was 3.85 points higher than the established criterion, indicating a significant improvement in skill mastery across all assessment dimensions—visual testing, fracture testing, bending testing, assembly precision, and safety compliance. This demonstrates that the learning intervention successfully increased welders' skills to professional levels in the industrial welding area. As a result, it can be stated that the PRO-WELD Model significantly improved welders' skills in steel welding utilizing the SMAW procedure.

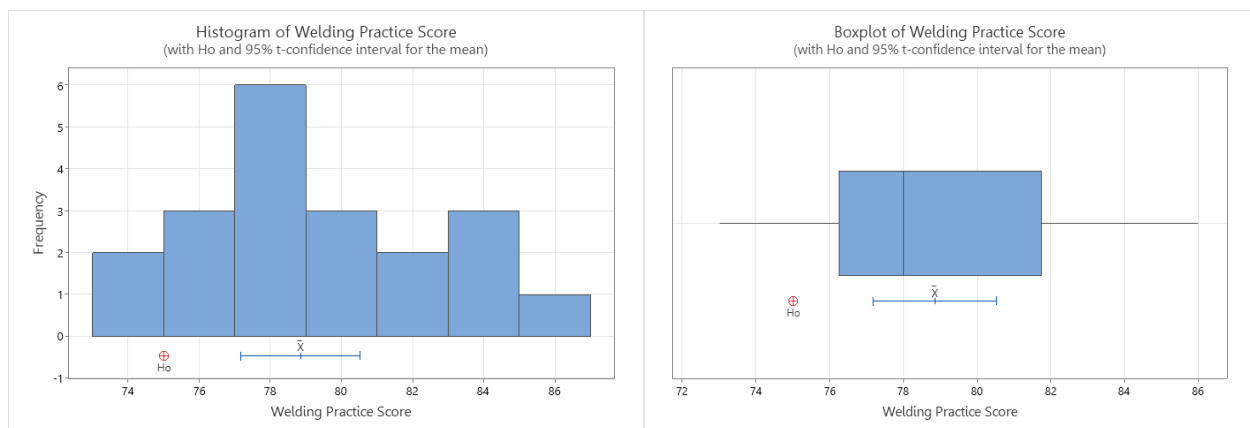


Figure 5. Histogram and Boxplot of Post-Test Skill Scores in Steel Welding Using the SMAW Process after Learning with the PRO-WELD Model

From Figure 5, the histogram and boxplot of post-test skill scores in SMAW indicate that most learners scored above the benchmark of 75 points. The score distribution followed a normal trend, with the median positioned at a high level. These findings are consistent with the statistical analysis, which demonstrated that the post-test scores significantly differed from the benchmark at the .05 level ($p < .05$). This supports the hypothesis $H_1: \mu \neq 75$, confirming that the learning model had a statistically significant impact on the development of learners' welding skills.

Table 10. Comparison of Post-Test Welding Competency Results after Learning with the PRO-WELD Model and the Competency Assessment Results According to Professional Standards and Qualifications in the Industrial Welding Profession: Shielded Metal Arc Welder Level 2.

Test	N	Mean	S.D.	SE. Mean	T-Value	P-Value
Post-test	20	78.250	2.677	0.599	-6.48	0.00
Occupational Standards		80.115	2.733	0.611		

Results of the Comparison between Welding Competency Assessment after Learning with the PRO-WELD Model and the Competency Assessment Based on Professional Standards and Qualifications in the Industrial Welding Profession: Shielded Metal Arc Welder, Level 2. A one-week interval was provided prior to the official competency assessment to allow welders to review the lessons and practice welding skills further before undergoing the professional standards and qualifications assessment conducted by an accredited certification body. The findings revealed that

all welders successfully passed the competency assessment according to the standards of the Industrial Welding Profession, Shielded Metal Arc Welder, Level 2, with an average score of 80.11%. Moreover, the comparison between the welding competency assessment scores obtained after learning with the PRO-WELD Model and those obtained from the professional standards and qualifications assessment showed a statistically significant difference at the 0.05 level ($p < 0.05$), as presented in Table 10. These results are consistent with the hypothesis $H_1: \mu \text{ difference} \neq 0$, indicating that the post-training competency scores achieved through the PRO-WELD Model and the professional competency assessment scores differ significantly. Therefore, it can be concluded that the PRO-WELD Model effectively enhanced the welding competency of welders, enabling them to meet and pass the criteria set by the professional standards and qualifications for the Industrial Welding Profession, Shielded Metal Arc Welder, Level 2.

In addition to statistical significance, the degree of the difference between the two assessments was examined using Cohen's d , which is an indicator of the practical effect size. The Computed Cohen's d was 0.97, indicating a large effect size based on Cohen's (1988) criteria. This finding demonstrates that the PRO-WELD Model has a significant and meaningful influence on improving welder abilities. In practical terms, this large effect shows that the improvement in welding performance was not only statistically significant, but also educationally and professionally relevant, demonstrating the model's efficacy in achieving measurable learning outcomes that are aligned with occupational standards. As a result, it can be concluded that the PRO-WELD Model significantly contributes to both skill mastery and welder readiness to meet professional qualification requirements, highlighting its practical applicability for workforce competency development in Thailand's industrial welding sector.

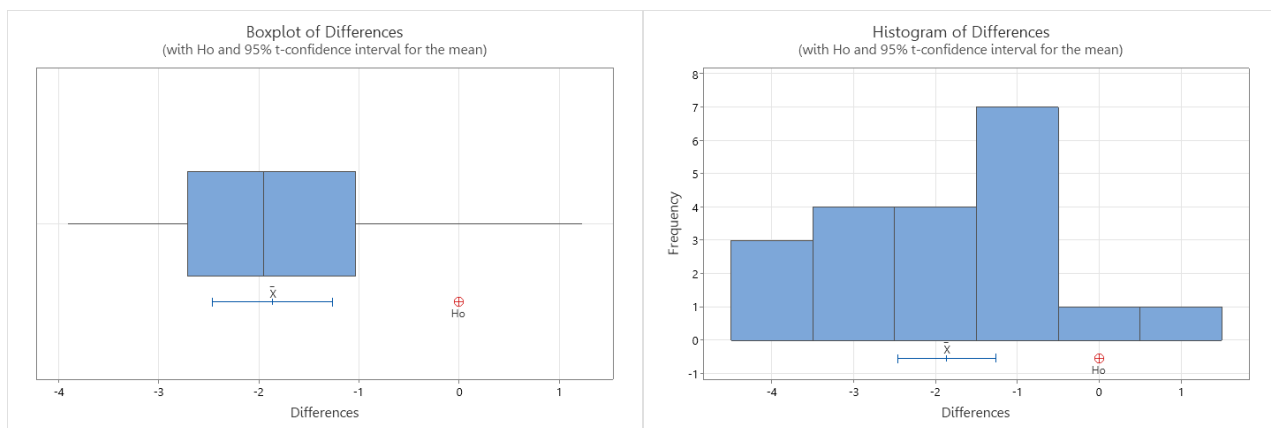


Figure 6. Histogram and Boxplot of Differences in Welding Competency Assessment Scores after Learning with the PRO-WELD Model and the Competency Assessment Based on Professional Standards and Qualifications in the Industrial Welding Profession: Shielded Metal Arc Welder, Level 2

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From Figure 6, the histogram and boxplot of the score differences between the welding competency assessment after training with the PRO-WELD Model and the assessment based on professional standards clearly demonstrate that the majority of welders achieved post-training scores higher than the established professional benchmark. Statistical testing confirmed that the difference between the two sets of scores was significant at the 0.05 level ($p < 0.05$), consistent with the alternative hypothesis $H_1: \mu \text{ difference} \neq 0$. Therefore, it can be concluded that the PRO-WELD Model has a positive effect on enhancing the welding competency of welders.

Table 11. Results of Welders' Satisfaction Assessment of the PRO-WELD Model

Evaluation Item	$\bar{X}$	SD	Satisfaction Level	Rank
1. Content	4.43	0.72	High Satisfaction	5
2. Learning Management Process	4.48	0.68	High Satisfaction	4
3. Learning Media	4.53	0.73	Highest Satisfaction	3
4. Assessment	4.75	0.49	Highest Satisfaction	1
5. Benefits Received	4.73	0.59	Highest Satisfaction	2
Overall Mean	4.58	0.64	Highest Satisfaction	

Results of Welders' Satisfaction Assessment toward the PRO-WELD Model. The satisfaction assessment of welders toward the PRO-WELD Model encompassed five dimensions with a total of 20 evaluation items. According to Table 11, the overall satisfaction level was rated at the highest level ($\bar{X}$ = 4.58, SD = 0.64). Among the dimensions, the highest satisfaction was reported for assessment ($\bar{X}$ = 4.75, SD = 0.49), followed by perceived benefits ($\bar{X}$ = 4.73, SD = 0.59) and learning media (M = 4.53, SD = 0.73). Satisfaction with the learning process ($\bar{X}$ = 4.48, SD = 0.68) and content ($\bar{X}$ = 4.43, SD = 0.72) was rated at a high level. Therefore, it can be concluded that welders' satisfaction with the PRO-WELD Model was consistent with the research expectations, confirming that the model effectively met the needs of learners.

5. Discussion

The objective of this study was to develop a BL integrated with the CBL model to enhance the competencies of welders in accordance with the occupational standards and professional qualifications of Thailand's industrial welding sector, as well as to examine the effectiveness of its implementation.

The analysis of welders' learning needs revealed that they consistently expressed the highest level of demand across all items, particularly in performing manual metal arc welding tasks according to work orders for fillet welds and groove welds, which achieved the highest mean score ($\bar{X}$ = 4.95, S.D. = 0.44). This finding reflects welders' awareness of the importance of developing competencies aligned with occupational standards and qualifications. The strong demand for practical skills aligns with the findings of Kifta, Ambiyar, Lapisa, and Zagoto (2023), who demonstrated that the Competence-Based Education and Training (CBET) method significantly enhanced learners' welding skills recognized at both national and international levels. Similarly, Pribadi and Shinoda (2025) reported that learners sought to acquire advanced welding skills and undergo evaluations in accordance with occupational standards. Furthermore, global comparisons reveal that BL-CBL approaches have produced similar results in other settings where they have been applied. For example, studies in Germany and Australia (Peters, 2021; Zhong & Juwaheer 2024) show that combining blended delivery with competency-based frameworks improves both technical and soft skills among vocational learners, resulting in higher employability and professional certification rates. Similar findings have been found in Japan and South Korea, where national certification systems prioritize hands-on learning using blended modalities, ensuring uniform skill recognition across industries. These parallels indicate that the Thai BL-CBL approach follows a global trend of connecting vocational training with real-world occupational norms.

The quality and appropriateness of the developed learning model, as evaluated by experts, was rated at the highest level overall ($\bar{X}$ = 4.67, S.D. = 0.50). Notably, the objectives of the model,

competency certification processes, learning model components, and learning media received the highest mean scores. This indicates that the structure of the developed learning model was consistent with the direction of professional standards and was applicable in real-world industrial welding contexts. These results correspond with the findings of Lee et al. (2023), who emphasized that an effective learning model should incorporate learning media (sensors, real-time feedback, visual cues), performance assessment, and quality training activities. Similarly, Liao et al. (2023) highlighted that the evaluation of competency indicators for welding by experts prioritizes multiple aspects, thereby underscoring the importance of comprehensive assessment in model design.

The quality of the learning manual was also rated at the highest level ($\bar{X} = 4.67$, S.D. = 0.50), especially in terms of its content and structure, the application of technology and learning media, as well as clarity and practical applicability. This finding indicates that the supporting documents were comprehensive and user-friendly. Such results are consistent with Phonngong and Keeratichamroen (2023), who argued that clear learning manuals with appropriate technological integration facilitate the effective implementation of CBL and support dissemination among instructors across diverse contexts. Similarly, the developed lesson plans were assessed at the highest level of quality ($\bar{X} = 4.71$, S.D. = 0.50), particularly regarding learning objectives, content, learning processes, assessment and evaluation, and practical feasibility. This demonstrates that the learning plans were clearly structured, implementable, and effective in enhancing learners' competencies. This aligns with the work of Safriwardy, Nasrah, and Wansah (2022), who stressed the importance of expert evaluations of both content and learning media to ensure the quality and applicability of learning modules in instructional contexts.

The experimental implementation of the learning model with welders yielded an efficiency score of $E1/E2 = 78.35/77.45$, which exceeded the predetermined criterion (70/70). This indicates that the developed model enabled learners to achieve the intended learning outcomes both during the learning process (E1) and after completion (E2). These findings support the CBL approach, which emphasizes real-world performance outcomes and continuous practice. Consistent with this, Kifta et al. (2023) demonstrated that CBET implementation in vocational schools significantly improved welding skills through practical training and competency-based assessment. Therefore, the findings of this research culminated in the development of the PRO-WELD Model, comprising six components: (1) principles of the learning model, (2) objectives of the learning model, (3) instructional methods, (4) technology and learning media, (5) assessment and certification of occupational standards and qualifications, and (6) roles of instructors and learners. Collectively, these components aim to enhance welders' competencies in alignment with occupational standards and professional qualifications. Based on the findings of the study on the effectiveness of the PRO-WELD Model, the comparison of learning achievement in steel welding through the SMAW process demonstrated that the PRO-WELD Model significantly improved learners' achievement in welding performance ($p < 0.05$), consistent with the proposed hypothesis. This result aligns with the principles of CBL(CBL), wherein learning models emphasizing competency development enable learners to practice and continuously assess their performance, thereby fostering skills directly aligned with industrial demands. This is consistent with the study of Sisay Abera Belayneh and Prof. Doing Xianhui (2024), which highlighted the importance of evaluating the quality and relevance of competency-based training in enhancing learners' skills across disciplines.

Furthermore, the assessment scores of welders in steel welding through the SMAW process, after applying the blended and CBLmodel, were significantly different from the established criterion ($\mu = 75$) at the 0.05 level ($p < 0.05$). This indicates that the model effectively enhanced manual welding skills. Such findings underscore the critical role of repetition and structured practice-oriented learning, which are central to competency-based learning, in advancing learners' competencies to meet occupational standards. These results are consistent with the study of Achmad Romadin, Didik

Nuhadi, and Yoto Yoto (2023), which reported that practice-intensive and competency-based assessment models significantly improved learners' welding performance and skill acquisition.

From the comparative analysis of welding competency assessment after instruction using the PRO-WELD Model and the assessment based on professional standards and qualifications in the field of Shielded Metal Arc Welder Level 2, it was found that all participants successfully passed the professional standards criteria, with an average score of 80.11%. The difference was statistically significant ($p < 0.05$), consistent with the hypothesis $H_1: \mu \text{ difference} \neq 0$. This demonstrates that the PRO-WELD Model effectively elevated welders' competencies to a level recognized by professional certification bodies. This finding aligns with the study of Pribadi & Shinoda (2025), which reported that welding competencies can be systematically categorized and enhanced through feedback and multi-level assessment (six skill levels). Similarly, the work of Ardian, Syauqi, & Sugiyono (2023) emphasized key strategies such as intensive mentoring, teacher-led evaluation, and expanded opportunities for practice, all of which significantly improved welding performance and learning outcomes.

Regarding welders' satisfaction with the learning model, the results revealed consistently high levels of satisfaction across all dimensions. The assessment dimension received the highest score ($\bar{X} = 4.75$, $SD = 0.49$), followed by perceived benefits ($\bar{X} = 4.73$, $SD = 0.59$) and learning media ($\bar{X} = 4.53$, $SD = 0.73$). These results highlight that the PRO-WELD Model effectively addressed the learning needs of welding professionals, particularly in the area of assessment, which is a critical factor in indicating competency levels based on occupational standards. The highest satisfaction with assessment may reflect the clarity, relevance, and alignment of the evaluation tools with actual job tasks, ensuring that learners' capacities were authentically demonstrated. This resonates with the principle of CBL(CBL), which prioritizes tangible learning outcomes assessed through performance-based methods (Mulder, 2022). The high scores in the perceived benefits dimension further indicate that learners were able to effectively transfer the acquired knowledge and skills to real-world contexts, reflecting the success of BL approaches that integrate theoretical instruction with practical application (Romadin, Nuhadi, & Yoto, 2023). Learning media also played a critical role in learners' satisfaction, particularly digital resources and instructional videos, which enabled learners to review content repeatedly according to their needs and supported learners with varied prior knowledge. This finding is consistent with Espiritu Bersamin et al. (2024), who noted that the integration of technology in vocational training enhances comprehension and fosters flexible learning. Although the learning process and content dimensions scored slightly lower than other dimensions, they still reached a high satisfaction level, suggesting that the instructional content and delivery were generally appropriate for learners in the welding profession. Nevertheless, some aspects could be improved, such as linking content more explicitly to real workplace problems or tailoring activity sequences to suit learners' differing skill levels.

In conclusion, welders expressed high levels of satisfaction with the PRO-WELD Model across all dimensions, particularly in assessment and perceived benefits. These findings confirm the suitability of the PRO-WELD Model as an effective framework that meets the authentic learning needs of welding professionals, both in terms of learning quality and applicability to real industrial contexts.

6. Conclusion

The development of the PRO-WELD Model can be summarized as follows: it comprises six key components—(1) principles of the learning model, (2) objectives, (3) instructional procedures, (4) technologies and learning media, (5) assessment and certification aligned with occupational and professional qualification standards, and (6) roles of instructors and learners. The PRO-WELD model integrates blended learning and competency-based learning to provide a training framework that complies with occupational standards, ensures measurable outcomes through certification, and

maintains validity in the labor market within Thailand's industrial welding sector. The model has been proven effective in enhancing both theoretical understanding and practical welding competencies. Welders achieved high levels of satisfaction and successfully met the assessment criteria of the National Occupational Standards and Professional Qualifications for Shielded Metal Arc Welder Level 2. These findings confirm that the PRO-WELD Model effectively supports skill development, strengthens professional qualifications, and enhances employability and career advancement for welders in the Thai industrial context.

7. Suggestion

Future research should include long-term follow-up to investigate sustained skill retention, workplace performance, and employment outcomes, allowing for a more accurate assessment of the model's long-term impact. The PRO-WELD model should also be tested with larger populations, such as vocational students, jobless people, and informal workers, to determine its applicability in various circumstances. Furthermore, the creation and testing of technology-enabled learning aids, such as intelligent systems or simulation-based modules, may improve the model's effectiveness and scalability.

8. Limitation

This study has significant drawbacks. First, the study was done in Thailand's industrial welding sector, with a modest number of participants (15 in the pilot study and 20 in the main study). Although the R&D and mixed-methods methodology enabled in-depth research, the small sample size limits the findings' applicability to larger populations or other industrial environments.

Second, the study looked only at short-term learning outcomes, such as immediate achievement, welding performance, and learner satisfaction. Long-term factors including skill retention, job performance, and employment or career advancement were not considered. As a result, the long-term impact of the blended and competency-based training models is still unknown.

Third, while the instruments utilized were highly valid and reliable, including self-reported satisfaction data may add response bias. Furthermore, contextual elements in the participating workplaces were not regulated, which could have influenced learners' performance. These limitations highlight the need for future studies to use bigger and more diverse samples, broaden the research to various industrial sectors, and undertake longitudinal follow-up assessments to determine the training model's long-term effectiveness.

Declarations

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