PROTOTYPE BOILER TRAINER: ACCEPTABILITY AMONG FACULTY AND INDUSTRY EXPERTS FOR TVET INSTRUCTION

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ABSTRACT. *Industrial boiler systems play a crucial role in many technical-vocational fields, yet their complexity and safety risks limit opportunities for authentic student training. To address this, a prototype boiler trainer was developed to simulate boiler operations safely and cost-effectively. This developmental research employed a researcher-designed questionnaire validated by experts to evaluate the acceptability of the prototype boiler trainer. A purposive sample of 33 respondents, including eight faculty experts and 25 industry experts in Zamboanga City, assessed the trainer in terms of design, functionality, and manipulative operation. Descriptive statistics, including means and standard deviations, and an independent samples t-test were used to analyze the data. The findings revealed that both faculty experts and industry experts rated the trainer as highly acceptable across all parameters. The trainer's design, including its portable, well-structured, and safety-focused features, received strong positive evaluations. Functionality features such as monitoring instruments, water pump systems, and steam production capabilities were likewise rated highly acceptable. Manipulative operations simulating authentic boiler tasks, including pressure adjustment, burner ignition, and valve control, also achieved high acceptability. No significant difference was found between the acceptability ratings of faculty and industry respondents These results indicate that the prototype trainer effectively bridges the gap between theoretical learning and industry practice, providing a safe, practical, and pedagogically sound tool for skills development in technical-vocational education. The prototype boiler trainer is a viable instructional device for TVET programs, aligning with both educational and industry standards.*

Keywords: Boiler Prototype, Instructional Innovation, Safety, Skills Training, Technical-Vocational

INTRODUCTION

The idea for developing a prototype boiler was born out of the researcher's direct experience teaching industrial technology courses in a resource-limited setting. During boiler operation classes, it became increasingly evident that students struggled to grasp the concepts of heat exchange, steam generation, and safety mechanisms through textbooks alone. The absence of functional training equipment in the laboratory not only hindered students' learning but also limited their confidence in handling real-world equipment [21]. This observation prompted the researcher to innovate a low-cost, safe, and portable prototype boiler that could simulate industrial boiler operations. By bridging the gap between theoretical instruction and practical application, the prototype aimed to enhance student learning outcomes in technical-vocational education.

In industrial settings, boilers are indispensable components of operations requiring thermal energy—such as heating, sterilization, and power generation. Defined as enclosed vessels that heat water to produce hot water or steam, boilers are commonly employed across manufacturing, food processing, and energy sectors [6,37]. Due to their operational complexity and safety risks, they necessitate a high level of technical proficiency from their users [16, 37]. The increasing reliance on these systems in modern industries underscores the importance of training institutions preparing students with adequate practical knowledge of boiler operation.

However, replicating boiler systems in educational institutions is often impractical due to cost, safety, and space limitations. Industrial-grade boilers require specialized facilities, routine maintenance, and trained operators to mitigate risks such as pressure explosions or toxic emissions [35,52]. As such, many technical schools are left with outdated or no equipment, compelling instructors to rely solely on lectures and demonstrations [29,46,21]. This instructional gap compromises the development of hands-on skills and limits learners' preparedness for employment [34,48].

In Southeast Asia and other developing regions, such challenges are amplified by systemic limitations in infrastructure and funding. According to UNESCO Strategy for TVET 2022-2029 (2022), technical and vocational education and training (TVET) institutions often operate under constrained budgets, affecting their ability to acquire advanced training tools. These constraints widen the disconnect between education and actual industry demands, resulting in graduates who lack operational competence in machinery like boilers. The need for innovative, cost-effective, and safe instructional technologies is thus a critical imperative.

Instructional prototypes present a practical solution to this educational dilemma. Prototypes, particularly simulation-based models, have demonstrated effectiveness in enhancing student understanding of complex mechanical systems [50]. For instance, Tibor (2016) reported that students exposed to a calibration machine simulator outperformed peers in practical tests and demonstrated superior manipulative skills [42]. Prototypes offer the advantage of replicating industrial processes in a controlled environment, making them ideal tools for experiential learning in industrial technology courses [14].

Aligned with constructivist pedagogy, prototype-based instruction fosters active learning by enabling students to manipulate, test, and observe machinery principles firsthand. Using instructional devices like programmable logic controllers (PLCs) resulted in higher student engagement and better laboratory performance [5, 21]. Importantly, many such instructional tools can be fabricated using affordable, locally available materials—making them sustainable and context-appropriate for underfunded institutions. This approach not only enriches instruction but also encourages innovation among educators and learners.

Zamboanga Peninsula Polytechnic State University (ZPPSU), as a state university mandated to deliver industry-relevant education, continually explores strategies to align its training programs with labor market demands. Consistent with Republic Act No. 11187, the university has prioritized developing faculty-made instructional devices to support curriculum outcomes in industrial and vocational education. The fabrication of a prototype boiler trainer aligns with ZPPSU's broader mission to produce industry-ready graduates through competency-based instruction. By replicating real-world tools in instructional form, the university empowers learners with critical practical skills.

This study's innovative prototype boiler offers a tangible, low-risk, and budget-friendly solution for teaching boiler operation, heat transfer, and safety procedures. Its modular structure includes simplified systems for water heating, steam generation, and exhaust venting, making theoretical concepts observable and interactive. Moreover, it serves as a valuable demonstration tool for instructors to explain pressure regulation, combustion processes, and routine maintenance. Studies show that students trained with operational prototypes exhibit improved confidence, better retention, and enhanced skills readiness [29,14].

Nonetheless, before the prototype can be recommended for instructional use, it must undergo validation by relevant stakeholders—namely, industry experts and academe specialists. The Technology Acceptance Model (Davis, 1989) suggests that perceived usefulness and ease of use are strong determinants of technology adoption. In education, these perceptions are shaped by practitioners' assessment of a tool's instructional value, accuracy, safety, and relevance to real-world conditions. Evaluating the prototype's acceptability ensures that it aligns not only with curriculum goals but also with the operational standards of the industries it intends to simulate [32, 18]

Given this context, the present study was conducted to evaluate the acceptability of a low-cost prototype boiler designed for instructional use in industrial technology courses. Specifically, the prototype was assessed by industry practitioners and academe experts in terms of its design, function, usability, and instructional value. Through this evaluation, the study aims to validate the prototype's potential for enhancing teaching and learning in boiler operation—a key competency area in many vocational programs. The results of this study will inform educators, curriculum developers, and institutional administrators in adopting instructional innovations that are both practical and pedagogically sound.

Ultimately, this study was guided by the evidence that meaningful learning in technical-vocational education hinges on access to contextualized, realistic, and safe instructional tools [52]. By documenting the development and validation of the prototype boiler, this research contributes to the growing field of educational technology innovation for industrial training. It also provides evidence-based recommendations for integrating low-cost simulators into TVET instruction, reinforcing the mission of educational institutions to produce technically skilled, job-ready graduates in alignment with industry needs.

Statement of the Problem

In technical-vocational education, the absence of accessible and safe training equipment remains a pressing challenge, especially for complex systems like industrial boilers. The researcher, having witnessed students' difficulty in grasping boiler concepts without hands-on experience, was compelled to design a low-cost, portable prototype boiler as an instructional aid. While the prototype offers a promising solution to bridge theory and practice, its effectiveness depends significantly on its acceptability among key stakeholders. Industry experts and technical education It is essential that academe must evaluate its design, usability, instructional value, and relevance to actual workplace conditions to ensure it meets both pedagogical and technical standards. However, limited studies have examined the acceptability of locally developed instructional boiler prototypes within the Philippine technical-vocational context. Therefore, this study was conducted to assess the acceptability of the prototype boiler as perceived by Academe experts and industry professionals to determine its potential integration into the teaching-learning process. Specifically, this study seeks to answer the following research questions:

1. How do academe and industry expert-evaluators assess the acceptability of the prototype boiler in terms of its design, manipulative operation, and functionality?
2. Are there significant differences in the acceptability ratings of the prototype boiler between academe and industry experts?

REVIEW OF RELATED LITERATURE

Boiler Fundamentals and Industrial Use

Boilers are integral components in industrial operations, primarily designed to convert water into steam for use in heating, sterilization, or mechanical energy generation. Industrial boilers utilize radiant, conductive, and convective heat transfer mechanisms and vary in design based on operational demands [27]. Water-tube boilers, in particular, dominate industrial applications due to their capacity to handle high pressures and rapid steam production. These systems necessitate precise water treatment processes, effective combustion, and periodic blowdown to maintain operational efficiency [12]. Water-tube boilers require proper water quality management to prevent scale buildup and corrosion inside the tubes, which can severely impact boiler efficiency and lifespan. Maintaining high-quality feedwater through treatment processes such as sediment filtration, water softening, deaeration, and chemical dosing is critical to avoid scale formation and corrosion damage. Regular maintenance practices including water testing, tube cleaning, and chemical treatment help ensure operational efficiency and prevent costly failures [40,20]. These design intricacies illustrate the complexity and precision required to operate industrial boilers safely and efficiently.

In the Philippines, the operation of boilers is highly regulated under the Labor Code (2015) and the Department of Labor and Employment's (DOLE) Boiler Rule 1160 (2002). These legal frameworks mandate permits for installation, operation, and inspection of steam boilers to ensure public safety. Regular jurisdictional inspections of boilers and pressure vessels, as emphasized by TÜV SÜD ARISE (Boiler and Pressure vessel Inspections, 2020), are fundamental for ensuring equipment is constructed, installed, and operated in compliance with applicable safety codes, thus preventing accidents such as explosions, fires, or toxic releases. However, within Philippine technical-vocational institutions, outdated or non-functional training equipment—such as boilers—remains commonplace, limiting students' opportunities for hands-on, real-world learning experiences [13]. As a result, trainees often lack essential practical exposure to operating and maintaining boiler systems under controlled conditions, highlighting a critical gap in vocational training that instructional prototypes like a low-cost boiler simulator could address [13]. Subsequently, graduates may enter the workforce without adequate training, such as exposure to the mechanical and operational intricacies of boilers, highlighting a gap in technical training that instructional prototypes could fill [38].

Safety, Operation, and Maintenance Practices

Ensuring proper safety protocols and maintenance is crucial in the operation of boiler systems. Comprehensive guidelines emphasize the need to prevent electrical hazards and thermal stress by promoting consistent and proactive maintenance practices [39]. Operating boilers beyond their specified design limits can result in corrosion, material fatigue, and even catastrophic failure [26]. Moreover, conducting annual safety valve tests and performing regular internal inspections is essential to prevent low-water conditions that could lead to boiler explosions [40]. These studies highlight that boiler operation demands not only theoretical knowledge but also strong technical skills in safety and maintenance procedures.

Philippine regulations reflect international safety standards through mandatory certifications, operational protocols, and periodic inspections. However, enforcement at the institutional level remains inconsistent [3,23] due to limited access to operational equipment and training facilities [44]. Studies notes that while technical-vocational education and training (TVET) programs cover equipment safety in theory, practical application is often missing [33]. This disconnection results in students graduating with limited skills in routine maintenance and emergency response related to boiler systems. The development of a prototype trainer can address this shortfall by simulating real-world scenarios in a controlled, low-risk educational environment.

Simulation-Based Learning and Instructional Impact

Simulation-based learning (SBL) is increasingly recognized as a powerful tool across disciplines, including technical education [25,2] found that SBL enhances students' confidence, knowledge retention, and practical skill application, especially in high-risk fields like healthcare and engineering. Similarly, studies report that virtual simulations of industrial processes allow learners to practice critical tasks without physical hazards, reinforcing procedural knowledge and operational competence (Bergama, Streng, de Carvalho, Rosenkranz, & Ghorbani, 2022). These findings support the integration of simulation devices into curricula to improve students' readiness for complex technical tasks.

In the Philippine context, [3] advocate for constructivist approaches in STEAM education, emphasizing hands-on experiences. Similarly, studies show that locally developed instructional devices, such as instructional learning objects [46]), programmable logic controllers [21] and motor control trainers [7], significantly enhance cognitive and psychomotor outcomes among technology students. [11]developed and assessed a pneumatic compressor trainer that improved student performance while reducing costs. However, there remains a notable absence of prototype trainers for boiler systems in the local literature. The development of such trainers is essential for equipping students with the competencies required in industrial environments.

Prototype Devices and Acceptability Studies

Educational prototypes have long been used to replicate industrial systems for instructional purposes. Studies have shown that prototype steam engines, for example, enhance students' understanding of thermodynamic principles and mechanical systems [28, 22, 17] further emphasized the benefits of prototype-based virtual environments in process safety training. These instructional devices not only mirror real-world industrial scenarios but also encourage critical thinking, problem-solving, and operational skills. Ultimately, prototype trainers help bridge the gap between theoretical concepts and practical application by providing a hands-on interface for learning.

Filipino educators have effectively developed and integrated prototype trainers into technical-vocational education (TVET) curricula. For example, [4] found that a validated vehicle electrical security system trainer significantly improved students' performance in automotive technology courses. Likewise, [43] demonstrated that instructional devices, such as a modularized photovoltaic system trainer, enhanced both learning engagement and assessment outcomes. These innovations have proven to be cost-effective, sustainable, and highly relevant to the local educational context. However, despite these advances, no research has yet focused on the design, development, or validation of a boiler prototype for instructional use — revealing a critical gap that this study seeks to address.

While global and local literature underscore the benefits of simulation and prototype training in technical education, few studies have focused on the development of instructional devices for steam boiler systems. Most existing prototypes pertain to automotive, electronics, and general mechanical systems. Furthermore, the acceptability of such devices—especially from both academe experts and industry professionals—has not been systematically assessed in the Philippine context. This gap underscores the urgent need for localized, low-cost, and instructionally validated boiler trainers.

More importantly, the integration of a prototype boiler trainer into the curriculum holds transformative potential for technical education in the Philippines. It can significantly improve the preparedness of students by offering experiential learning opportunities that mirror industrial realities. Through exposure to scaled-down yet functionally accurate systems, students can develop the technical proficiency, safety awareness, and operational confidence required in the workplace. By validating the trainer's acceptability among key stakeholders, this study aims to contribute to a more responsive and practice-oriented educational system that supports the transition of graduates into competent industry professionals.

METHODOLOGY

Research Design

This study employed a developmental research design, a well-established methodology in the field of instructional technology. Developmental research integrates both theory and practical application by focusing on the systematic design, development, and evaluation of instructional products, processes, and programs to enhance learning outcomes [45]. Developmental research refers to studies that not only involve creating educational tools but also examining the process of their development to ensure effectiveness and internal consistency. The developmental nature of this research makes it particularly suited for the present study, which involves the construction and validation of a prototype boiler trainer intended for instructional use in technical-vocational education.

Through this design, the researcher aimed to produce a functional and pedagogically sound instructional prototype that mirrors real-life boiler operations. More than simple product creation, the study systematically evaluated the prototype's design, usability, and instructional value based on feedback from academe and industry experts. The iterative nature of developmental research allowed for ongoing refinements to the trainer based on empirical data, thus ensuring its alignment with actual classroom and industrial needs.

Research Locale

This study was conducted in Zamboanga City, located in the Western Mindanao region of the Philippines, where two state universities offer technical-vocational and industrial technology programs relevant to boiler operations. These programs intersect with marine engineering, mechanical technology, and energy systems, making knowledge of boiler systems essential for student preparation. Strategically positioned in a dynamic urban area with a strong tourism and commercial presence, the university is well-placed to address regional workforce needs. Furthermore, the research included several industrial plants within Zamboanga City that rely on boiler systems for critical operations in energy generation, food processing, and manufacturing. This combination of academic and industrial environments created an ideal setting to develop and evaluate a prototype boiler trainer, ensuring its relevance and acceptability for both educational instruction and practical industry application.

Respondents of the Study

The respondents of the study were purposively selected academe and industry experts who possess relevant expertise in boiler systems and industrial operations. Table 1 presents the distribution of respondents. A total of 33 individuals participated: eight academe experts from two state universities (coded as SUC 1 and SUC 2) and 25 industry experts from three different industrial establishments (coded as IND 1, IND 2, and IND 3). This strategic selection of respondents ensured diverse perspectives, reflecting both instructional and operational expertise. The combination allowed the evaluation of the prototype in terms of educational relevance and real-world applicability.

Table 1.Distribution of Respondents

Respondents Category	Code	N	%
Academe Experts	SUC 1	5	15
	SUC 2	3	9
Industry Experts	IND1	10	30
	IND2	5	15
	IND3	10	30
Total		33	100

Research Instrument

The primary research instrument was a researcher-made survey questionnaire designed to measure the acceptability of the prototype boiler trainer. It utilized a five-point Likert scale with the following response options: 5 = Strongly Agree, 4 = Agree, 3 = Neither Agree nor Disagree, 2 = Disagree, and 1 = Strongly Disagree. The questionnaire assessed the prototype across several dimensions including design, functionality, and manipulative operation.

The instrument was composed of two main sections. Part I gathered demographic information of the respondents, such as years of experience and area of specialization. Part II contained the core evaluation items related to the acceptability of the prototype. Additionally, a cover letter was included to explain the study's purpose, assure confidentiality, and request informed consent.

Validity and Reliability of the Research Instrument

The validity of the research instrument was established through a panel of experts, including the researcher's adviser and academic evaluators. These experts reviewed the questionnaire items for clarity, relevance, and alignment with the study's objectives. Each item was critiqued for its appropriateness in evaluating the prototype's instructional and technical attributes. Feedback from the panel was incorporated into the revised version of the questionnaire to enhance content validity.

For reliability testing, the revised instrument was administered to 25 non-participant respondents with similar characteristics to the target population. Cronbach's alpha coefficient was used to measure internal consistency. A value above 0.70 was considered acceptable [24], ensuring that the instrument yielded consistent and reliable results.

Data Gathering Procedure

The data collection process began with securing formal permission from the university president and the relevant department heads. Additionally, letters of permission were sent to managers of industrial plants within Zamboanga City to obtain their approval for conducting the study in their facilities. Once these permissions were granted, the researcher personally distributed the questionnaires to academe experts and industry professionals, providing both a verbal and written explanation of the study's objectives. Participants were assured of voluntary participation, anonymity, and confidentiality, with the option to withdraw from the study at any time without any negative consequences.

After collection, completed questionnaires were immediately retrieved to maximize the response rate and preserve data integrity. All responses were compiled, encoded, and subjected to analysis using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including mean and standard deviation, were employed to evaluate the level of acceptability of the prototype boiler trainer across various domains. The results were further analyzed to identify the strengths of the prototype as well as potential areas for improvement to enhance its design and instructional application.

RESULTS AND DISCUSSION

Assessment of the Prototype Boiler's Design, Manipulation Operation, and Functionality by Academe and Industry Experts

In Terms of Design

The evaluation results revealed that both academe experts and industry experts rated the design of the prototype boiler trainer as highly acceptable, with an overall mean of 4.67 for academe experts and 4.56 for industry experts. Among the specific items, the trainer's proper installation and its incorporation of safety features achieved the highest mean ratings from academe (M = 4.87), while industry experts similarly rated these items as highly acceptable (M = 4.56 and 4.44, respectively). Statements regarding the structural frame's firmness, the appropriateness of dimensions for student practice, and its portability also received strong agreement across both groups, reflecting a consistent perception of quality and relevance. The consistently high means indicate a strong consensus that the prototype is structurally sound, safe, and instructionally appropriate for

Table 2. Level of Acceptability of the Proto-type Boiler Trainer as Evaluated by Academe Experts in Terms of Design.

Question Items for Design	Academe Experts		Industry Experts	
	Mean	Description	Mean	Description
1. The Structural Frame of the Prototype Boiler	4.75	HA	4.60	HA
2. The dimension/size of Prototype Boiler Trainer is appropriate for a single student to	4.62	HA	4.60	HA
3. The components in the Prototype Boiler Trainer are adequately spaced for efficient manipulation in the	4.50	HA	4.48	HA
4. The components of the Prototype Boiler Trainer are properly installed to provide	4.87	HA	4.56	HA
5. The components in the Prototype Boiler Trainer are organized	4.50	HA	4.64	HA
6. The Prototype Boiler Trainer over-all is designed to provide safety	4.87	HA	4.44	HA
7. The Prototype Boiler Trainer is portable that could be easily placed from one area to	4.62	HA	4.60	HA
Over-all Mean	4.67	HA	**4.56**	HA

Parameters: 4.21–5.0 (HA- Highly Acceptable); 3.41–4.20 (A-Acceptable); 2.61–3.40 (Neutral); 1.81 – 2.6 (U-Unacceptable); 1.0-1.80 (HU-Highly Unacceptable).
= 4.50, *SD* = 0.52; industry: *M* = 4.68, *SD* = 0.48),

student learning in boiler operation, aligning with acceptable instructional design standards [47].

The highly acceptable ratings from both academic and industry evaluators can be attributed to the prototype's thoughtful, re-engineered features, which combine structural integrity, safety, and learner-centered usability. Its durable steel frame, lockable wheel casters, appropriate working dimensions, and well-organized component layout provide a realistic and ergonomic simulation of actual boiler systems, encouraging hands-on, safe, and efficient skills practice.

These features support the findings of [1], which emphasize the role of instructional design in creating focused and engaging learning tools that address students' needs. Additionally, the prototype's embedded safety features—such as relief valve, pressure switch, and clear monitoring instruments—reflect best practices in industrial safety [40, 39], thus reassuring both educators and practitioners of its appropriateness for teaching. The results highlight that a properly designed prototype can bridge theory and practice, enhancing technical-vocational education by providing a secure and realistic environment for students to build the skills expected by industry [8,32] Table 2 presents the results of data analysis for the design of the prototype.

In Terms of Manipulative Operation

The prototype boiler trainer was rated as highly acceptable in terms of manipulative operation by both academe experts (M = 4.57, SD = 0.18) and industry experts (M = 4.66, SD = 0.10). Among the highest-rated items were the operation of the main circuit breaker (academe: M = 4.75, SD = 0.46; industry: M = 4.80, SD = 0.40), the main steam valve (academe: M = 4.75, SD = 0.46; industry: M = 4.76, SD = 0.43), and the gate valve for water supply (academe: M = 4.75, SD = 0.46; industry: M = 4.68, SD = 0.47), indicating strong agreement on the trainer's capacity to replicate authentic mechanical operations. Slightly lower yet still acceptable ratings were noted for the solenoid valve operation (academe: M = 4.12, SD = 0.62; industry: M = 4.48, SD = 0.50), suggesting a need to enhance this feature to better simulate automatic shut-off functionality.

These findings reflect the prototype's effectiveness in facilitating sequential operational learning, offering realistic, hands-on opportunities to develop the manipulative competencies required for boiler system tasks. operation reflects the thoughtful integration of the high level of acceptability for manipulative components that mirror industry-standard boiler controls, allowing students to practice realistic starting, running, and shutdown procedures. Features such as the water pump switch, air vent valve, drain valves, and pressure adjustment knob were designed to be both accessible and intuitive, promoting safe and repetitive skills practice essential for building procedural fluency [2].

The positive evaluation from industry experts further validates the prototype's potential to address the skills gap often observed in technical-vocational education, where limited access to live equipment constrains competency-based learning. The trainer's authentic simulation of operations, supported by sound design and safety features, directly contributes to bridging theory and practice, empowering students with critical competencies to meet industry standards [28,41]. Table 3 presents the results of data analysis for the manipulative operation of the prototype.

In Terms of Functionality

An analysis of the prototype boiler trainer's functionality indicated a high level of acceptability among academe experts (*M* = 4.65, *SD* = 0.10) and industry experts (*M* = 4.68, *SD* = 0.09), both falling within the *highly acceptable* descriptive range (4.21–5.0). Among specific functionality items, the trainer's capacity to support boiler unit water level monitoring was rated highest by academe experts (*M*

= 4.75, *SD* = 0.43) and closely matched by industry experts (*M* = 4.72, *SD* = 0.45). The feature enabling water pump operation was also rated highly acceptable (academe: *M* = 4.75, *SD* = 0.46; industry: *M* = 4.68, *SD* = 0.48). Other elements, such as the provision of steam for sterilization (academe: *M* = 4.62, *SD* = 0.50; industry: *M* = 4.72, *SD* = 0.47) and the presence of safety monitoring devices including pressure gauges, indicator lights, and temperature gauges (academe: *M* were also strongly endorsed.

The results demonstrate consistent agreement among both faculty and industry experts that the prototype boiler trainer successfully replicates core boiler system functions, supporting realistic, practice-based student learning aligned with technical-vocational education objectives. The

Table 3. Level of Acceptability of the Proto-type Boiler Trainer as Evaluated by Academe Experts in Terms of Manipulative Operation

Question Items for Manipulative Operation	Academe Experts		Industry Experts	
	Mean	Description	Mean	Description
1. The Prototype Boiler Trainer could provide students the operation to open and close the gate valve for water supply.	4.75	HA	4.68	HA
2. The Prototype Boiler Trainer could provide students the operation to switch ON and OFF the water pump for providing water supply to the boiler system.	4.37	HA	4.76	HA
3. The Prototype Boiler Trainer could provide students the operation for LPG burner to ignite and a tank valve to open or close the LPG gas.	4.62	HA	4.68	HA
4. The Prototype Boiler Trainer could provide students the operation to release the air inside the boiler by means of air vent valve.	4.62	HA	4.52	HA
5. The Prototype Boiler Trainer could provide students the operation to remove sludge or impurities of water from the boiler unit.	4.5	HA	4.60	HA
6. The Prototype Boiler Trainer could provide students the operation to set the steam pressure using pressure adjustment knob to automatically shut-off the boiler system when it each the required pressure.	4.62	HA	4.72	HA
7. The Prototype Boiler Trainer could provide students the operation to automatically shut-off the supply of LPG to the burner when the boiler is off by means of solenoid valve.	4.12	A	4.48	A
8. The Prototype Boiler Trainer could provide students the operation of the main steam valve to allow the flow of steam product.	4.75	HA	4.76	HA
9. The Prototype Boiler Trainer could provide students the operation of ON/OFF switch that serves as the main breaker of power supply to the boiler system.	4.75	HA	4.80	HA
10. The Prototype Boiler Trainer could provide students the operation of removing sludge and impurities inside water tank by means of water tank drain valve.	4.62	HA	4.64	HA
Over-all Mean	**4.57**	HA	**4.66**	HA

Parameters: 4.21–5.0 (HA- Highly Acceptable); 3.41–4.20 (A-Acceptable); 2.61–3.40 (Neutral); 1.81 – 2.6 (U-Unacceptable); 1.0-1.80 (HU-Highly Unacceptable).

Table 4. Level of Acceptability of the Proto-type Boiler Trainer as Evaluated by Academe Experts in Terms of Functionality

Question Items for Functionality	Academe Experts		Industry Experts	
	Mean	Description	Mean	Description
1. The Prototype Boiler Trainer can provide steam that used as sterilizer for specific utilization.	4.62	HA	4.72	HA
2. The Prototype Boiler Trainer provides a safety device such as pressure gauge, indicator lights and temperature gauge for monitoring the condition of boiler operation.	4.5	HA	4.68	HA
3. The Prototype Boiler Trainer can provide system starting procedure.	4.62	HA	4.64	HA
4. The Prototype Boiler Trainer can provide system for water pump operation.	4.75	HA	4.68	HA
5. The Prototype Boiler Trainer can provide boiler unit for water level monitoring.	4.75	HA	4.72	HA
Over-all Mean	**4.65**	HA	**4.68**	HA

Parameters: 4.21–5.0 (HA- Highly Acceptable); 3.41–4.20 (A-Acceptable); 2.61–3.40 (Neutral); 1.81 – 2.6 (U-Unacceptable); 1.0-1.80 (HU-Highly Unacceptable).

consistently high functionality ratings can be attributed to the prototype's well-integrated and authentic design features, which closely replicate the performance standards required in real-world industrial boiler systems. The inclusion of safety monitoring instruments, reliable water level management, and a fully functional start-up process creates a realistic and engaging environment for learners to practice essential operational skills [41,39. This level of realism helps build learners' confidence and competence in operating boilers safely, aligning with instructional design principles that emphasize experiential and practice-based learning [28]. Furthermore, the prototype's ability to simulate the functional interdependence of boiler components addresses critical skills gaps in many TVET programs where industrial equipment is inaccessible (TESDA, 2024). Table 4 presents the results of data analysis for the functionality of the prototype.

Comparative Analysis of Acceptability Ratings Between Academe Experts and Industry Professionals

An independent samples t-test was conducted to determine whether there was a significant difference in the level of acceptability of the prototype boiler trainer between industry experts (M = 4.64) and faculty experts (M = 4.63). The results showed a t-value of 0.021 with a p-value of 0.983, which is greater than the alpha level of 0.05. Based on this, the null hypothesis was not rejected, indicating that there is no statistically significant difference in the acceptability ratings of the prototype boiler trainer between the two groups of evaluators. This suggests that both industry professionals and academic faculty share consistent perspectives on the acceptability of the trainer as an instructional tool.

CONCLUSION

Based on the results of the data analysis, it can be concluded that both faculty experts and industry experts assessed the prototype boiler trainer as highly acceptable in terms of its design, functionality, and manipulative operation. The high mean scores across all evaluated domains indicate that the trainer meets the standards of a structurally sound, safe, and instructionally relevant mock-up that effectively simulates authentic boiler operations. The results confirm that the prototype trainer provides an engaging, realistic, and pedagogically sound opportunity for students to develop competencies in boiler system tasks, including starting, operating, monitoring, and safely shutting down boiler processes.

Table 4. Level of Acceptability of the Proto-type Boiler Trainer as Evaluated by Academe Experts in Terms of Functionality

Question Items for Functionality	**Academe Experts**		Industry Experts	
	Mean	**Description**	Mean	Description
1. The Prototype Boiler Trainer can provide steam that used as sterilizer for specific utilization.	**4.62**	**HA**	4.72	HA
2. The Prototype Boiler Trainer provides a safety device such as pressure gauge, indicator lights and temperature gauge for monitoring the condition of boiler operation.	**4.5**	**HA**	4.68	HA
3. The Prototype Boiler Trainer can provide system starting procedure.	**4.62**	**HA**	4.64	HA
4. The Prototype Boiler Trainer can provide system for water pump operation.	**4.75**	**HA**	4.68	HA
5. The Prototype Boiler Trainer can provide boiler unit for water level monitoring.	**4.75**	**HA**	4.72	HA
Over-all Mean	**4.65**	**HA**	**4.68**	HA

Parameters: 4.21–5.0 (HA- Highly Acceptable); 3.41–4.20 (A-Acceptable); 2.61–3.40 (Neutral); 1.81 – 2.6 (U-Unacceptable); 1.0-1.80 (HU-Highly Unacceptable).

Table 5. Significant The Difference in the Level of Acceptability of the Prototype Boiler among Industry and Faculty Experts

Type of Respondent		t-value	p-value	Decision	Interpretation
Industry Experts	Academe Experts				
Mean	*Mean*				
4.64	4.63	.021	.983	Ho is not Rejected	Not Significant

Level of significance at 0.05 Level of significance at 0.05The high mean scores across all

The absence of a significant difference between the acceptability ratings of industry and faculty experts highlights the strong consensus that the prototype boiler trainer is both pedagogically and technically sound for instructional purposes. This alignment suggests that the trainer successfully meets the expectations of both those who will use it in educational settings and those who understand the practical demands of industry. As emphasized by [41] and supported by instructional design frameworks [47], ensuring that training devices satisfy the standards of both industry and academe is critical for effective skill transfer. The findings imply that the trainer is well-positioned to bridge the gap between classroom learning and workplace requirements, providing a realistic, safe, and contextually relevant means for technical-vocational students to develop the competencies demanded by employers. This consensus strengthens the case for integrating the prototype boiler trainer into TVET programs as a reliable instructional innovation that supports industry-aligned skills development. Table 5 presents the results of analysis of the data.

Furthermore, there was no significant difference between the acceptability ratings of industry experts and faculty experts, as indicated by the non-significant t-test result (p = .983). This consistent agreement suggests that the trainer is both educationally appropriate and technically aligned with industry practices. Therefore, the prototype boiler trainer can be considered a valid and practical instructional device for enhancing skills training in technical-vocational education programs, providing a cost-effective and safe bridge between classroom instruction and actual workplace requirements.

LIMITATIONS OF THE STUDY

A notable limitation of this study lies in its developmental research design and use of purposive sampling, which, while appropriate for prototype evaluation, restricts the breadth of generalization. The selection of respondents was limited to a small group of 33 faculty and industry experts within Zamboanga City, which may not fully represent the broader population of technical-vocational educators and industrial practitioners across the Philippines. Additionally, the relatively modest number of respondents may limit the statistical power of the findings, making it challenging to draw definitive conclusions about the trainer's acceptability in other contexts. These factors collectively suggest that while the results are promising, they should be interpreted with caution, and future studies with larger, more diverse samples and expanded research sites are recommended to validate and extend these findings.

RECOMMENDATIONS

In light of the study's findings, it is recommended that the prototype boiler trainer be integrated into technical-vocational education programs as an instructional device for teaching boiler system competencies. Its high acceptability ratings from both academe and industry experts indicate that it is structurally sound, instructionally relevant, and aligned with industry safety and operational standards. By adopting this trainer, schools and training institutions can provide students with authentic, hands-on learning opportunities that bridge the gap between classroom instruction and real-world industrial practices. Furthermore, industries could explore partnerships with educational institutions to utilize the trainer for upskilling new hires or retraining existing employees, thereby supporting workforce readiness and strengthening industry–academe collaboration.

Given the study's limitations related to the research design, purposive sampling, and relatively small respondent pool, it is recommended that future research replicate this evaluation with a larger, more diverse sample across multiple regions to enhance generalizability. Expanding stakeholder groups to include students and actual end-users of the trainer will provide richer insights into its practical impact on skill acquisition and performance. Additionally, longitudinal studies examining the trainer's durability, maintenance needs, and cost-effectiveness over time would be valuable to assess its long-term viability for broader implementation. By addressing these limitations, future investigations can build a more robust evidence base to support the sustainable integration of the prototype boiler trainer in technical-vocational education and industrial training programs.

Disclosure on the Use of Generative AI

This article utilized generative AI solely to enhance language clarity and coherence, without altering the original research findings or interpretations.

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