

Empowering Vocational Teachers Basic Safety Training through Partnership-Dual Training System Integration

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ABSTRACT

Introduction: Vocational education plays a pivotal role in preparing skilled human resources aligned with industry demands. However, productive teachers in automotive vocational high schools (SMKs) often exhibit gaps in occupational safety and health (OSH) competencies, adversely affecting workshop safety and graduate readiness. Traditional in-house training methods lack practical relevance and industry integration, necessitating innovative approaches.

Objective: This study aims to develop, validate, and implement a Partnership-Dual Training System (PADU) model for Basic Safety Training (BST) to enhance OSH competencies among productive teachers in private automotive SMKs in Kabupaten Deli Serdang, Indonesia.

Methods: A Research and Development (R&D) design following Borg and Gall's ten-step model was employed. Data were collected from 123 productive teachers across 41 private SMKs through training needs analysis, expert validation, and field testing. Quantitative data on knowledge and skills were analyzed using descriptive statistics, Shapiro-Wilk normality tests, paired t-tests, and normalized gain (N-Gain) calculations. Qualitative data from interviews and observations supported triangulation.

Results: Training needs analysis revealed significant competency gaps in OSH knowledge and practical skills. Expert validation confirmed the PADU model's content validity, relevance, and feasibility with mean ratings above 4.3 (scale 1–5). Implementation results showed statistically significant improvements in OSH knowledge (mean gain = 42.5, $p < 0.001$) and practical skills (mean gain = 36.5, $p < 0.001$), with moderate to high N-Gain scores (0.58–0.67). Qualitative feedback highlighted enhanced teacher engagement and confidence.

Conclusion: The PADU model effectively integrates theoretical and practical OSH training through school-industry partnerships, significantly improving vocational teachers' competencies. This model offers a sustainable framework to advance vocational education quality and workplace safety culture.

Keywords: Basic Safety Training (BST), Partnership-Training, Dual Training System (DTS), Automotive Teachers, Vocational High Schools (VHS)

INTRODUCTION

Vocational education in Indonesia plays a strategic role in preparing competent and workforce-ready human resources, as mandated by the Republic of Indonesia Law Number 20 of 2003 concerning the National Education System. Vocational High Schools (VHS) are an integral part of the secondary education system with the primary mission of producing skilled labor aligned with their fields of expertise [1], [2]. However, despite this noble vision, empirical evidence indicates that VHS graduates disproportionately contribute to unemployment rates in Indonesia. According to data from the Central Statistics Agency as of February 2022, 9.42% of national unemployment comprises VHS graduates, signaling a disparity between the institutional objectives of vocational education and labor market realities [3], [4]. This issue is exacerbated by the predominance of normative and adaptive teachers over productive teachers, coupled with limited relevant training aligned with industrial developments for VHS educators.

A central issue contributing to the low competitiveness of VHS graduates is the weak competency in occupational safety and health (OSH) among both students and teachers, particularly in practical learning within automotive workshops [5], [6], [7]. Non-standardized practicum activities that do not comply with OSH regulations have resulted

in a high incidence of occupational accidents within VHSs. Data collected from 10 private VHSs under the Regional Education Office Branch I of North Sumatra Province during 2018–2022 recorded 120 occupational accident cases, with the most frequent types being finger entrapment (25 cases) and vision impairment (22 cases). These incidents highlight inadequate implementation of fundamental OSH principles in student practice areas and indicate limited knowledge and skills among productive teachers in identifying and managing occupational hazards.

This phenomenon underscores the critical need for occupational safety and health training, particularly in the form of Basic Safety Training (BST), for productive teachers who serve as primary instructors for practical subjects [8], [9], [10]. Unfortunately, preliminary studies reveal that existing training tends to be formalistic, conducted internally (in-house training), and predominantly theoretical. Knowledge assessments of 10 productive teachers in private VHSs specializing in automotive engineering in Deli Serdang Regency showed an average score of only 36.4 (categorized as very poor), while skill observations indicated less than 50% proficiency in hazard identification. The failure to meet OSH competency standards poses significant risks to student safety and the quality of practical learning, which is the essence of vocational education [11], [12].

From a regulatory perspective, the government has established the importance of OSH in educational institutions through Government Regulation Number 50 of 2012 concerning the Occupational Safety and Health Management System (VHS3) and the Minister of Education and Culture Regulation Number 34 of 2018 concerning the National Education Standards for VHS. However, in practice, OSH implementation in education remains inadequately integrated, especially in private VHSs, which generally face resource constraints and limited access to professional training. Productive teachers in private VHSs not only lack industry-standard training but are also unfamiliar with safety instruments such as fire extinguishers, safety devices, and the appropriate use of personal protective equipment (PPE) as stipulated by the Indonesian Ministry of Manpower [13], [14].

From a training theory perspective, the prevailing approach relies heavily on traditional lecture methods, which have demonstrated several shortcomings. Previous studies have shown that lecture-based methods are ineffective in developing practical skills, tend to reduce participant engagement, and risk lowering material retention [15]. In the context of OSH training, which is highly practical and context-specific, there is a need for experiential and work-reality-based training models. This necessitates new training approaches, namely partnership-based training and the dual training system (DTS) [16], [17]. These approaches are considered capable of addressing the limitations of in-house training by providing direct industrial experience and fostering partnerships between educational institutions and the business sector.

The theoretical gap in this study lies in the underdevelopment of OSH training models for VHS teachers based on synergy between schools and industry, as well as the absence of a training design that balances theoretical and practical approaches. International literature demonstrates that dual training systems effectively enhance skills, participant engagement, and job readiness [18], [19], [20], yet their application in productive teacher training, particularly in automotive engineering fields in Indonesia, remains underexplored.

Furthermore, a research gap exists in the lack of studies developing OSH training models based on the Partnership-Dual Training System (PADU) specifically for productive teachers in private VHSs. Most research focuses on student training, neglecting the critical role of teachers as key actors in practical learning. Productive teachers are not only instructors but also managers of practice spaces, safety mentors, and role models in fostering a safe work culture. Therefore, strengthening OSH competencies among teachers will have a cascading effect on the quality of VHS graduates.

OBJECTIVES

The primary objective of this study is to develop an effective and practical management model for Basic Safety Training based on the Partnership-Dual Training System (PADU) to improve OSH competencies among productive teachers in private VHSs specializing in automotive engineering in Deli Serdang Regency. Specific objectives include: (1) describing the current OSH training models implemented in these schools; (2) designing a hypothetical training model tailored to the needs and characteristics of productive teachers; (3) developing a final PADU-based training model through expert and practitioner validation; and (4) testing the feasibility, effectiveness, and practicality of the model through limited implementation in partner schools.

By employing a needs-based approach grounded in robust theoretical concepts, this research aims to make a significant contribution to the development of VHS teacher training management in Indonesia. The outcomes will not only provide a training model and implementation tools but also promote a culture of safety in vocational education environments, ultimately enhancing graduate quality, occupational safety, and stronger linkages between education and industry (link and match). Additionally, the PADU training model holds potential for adaptation in other VHS expertise programs and development as a sustainable training program at regional and national levels.

LITERATURE REVIEW

The literature on training management provides a foundational framework for understanding how educational and professional development programs can be effectively designed, implemented, and evaluated, especially in vocational education settings such as automotive technical teacher training in VHS. Training management is broadly conceptualized as a systematic process encompassing the planning, execution, and evaluation of training activities aimed at enhancing the competencies of participants to meet organizational or institutional goals. Central to this concept is the recognition that effective training management requires alignment between training objectives, content, methods, and outcomes, ensuring that both individual and organizational needs are addressed.

Training Model

Various models of training management have been proposed in the literature, each emphasizing different aspects of the training process. Classical models typically follow a linear sequence of needs analysis, design, implementation, and evaluation, such as the widely adopted ADDIE model (Analysis, Design, Development, Implementation, Evaluation) [21], [22]. Other models incorporate feedback loops and continuous improvement cycles to adapt training programs dynamically. More contemporary approaches integrate partnership and industry collaboration, recognizing the importance of contextual and experiential learning environments. The Partnership-Dual Training System (PADU) model exemplifies this trend by combining school-based theoretical instruction with workplace-based practical training, fostering synergy between educational institutions and industry partners [23], [24]. This model is particularly relevant for vocational teacher training, where hands-on skills and safety competencies are critical.

Effective Training Management

Indicators of effective training management extend beyond mere participant satisfaction to include measurable improvements in knowledge, skills, and attitudes, as well as behavioral changes and organizational performance enhancements [25], [26]. Common indicators include training relevance, participant engagement, transfer of learning to the workplace, and impact on job performance. In vocational education, especially in technical fields, additional indicators such as adherence to safety standards and reduction of workplace accidents are crucial metrics. These indicators serve as benchmarks for continuous monitoring and evaluation, enabling trainers and managers to refine their programs iteratively [27], [28].

Training Typology

Training typologies in the literature are diverse, ranging from formal instructor-led sessions to informal on-the-job training and blended learning approaches. In the context of vocational education, training types often include technical skills training, safety training, pedagogical training for teachers, and soft skills development. Basic Safety Training (BST), which focuses on foundational occupational safety and health (OSH) principles, is a specialized form of training that addresses the critical need for safe work practices in technical workshops [29], [30], [31]. BST aims to equip both teachers and students with the knowledge and skills necessary to identify hazards, use personal protective equipment correctly, and respond to emergencies effectively.

Indicators of Training Programs

The success of training programs is influenced by multiple factors, including organizational support, trainer competence, participant motivation, training design, and resource availability. Organizational culture and leadership commitment to safety and quality education play pivotal roles in fostering an environment conducive to effective training [32]. Additionally, the relevance of training content to actual workplace demands, the use of experiential

learning methods, and the integration of industry standards significantly enhance training outcomes. In vocational teacher training, the dual role of teachers as educators and workplace safety role models underscores the importance of comprehensive and contextually relevant training programs [33], [34].

Training Processes

Training processes are **generally** structured into sequential stages: training needs analysis, planning, implementation, and evaluation. Needs analysis is critical for identifying competency gaps and aligning training objectives with institutional goals and labor market requirements [35], [36]. Effective planning involves curriculum development, resource allocation, scheduling, and stakeholder engagement. Implementation must ensure active learning through practical exercises, simulations, and real-world exposure, particularly in technical and safety training [37]. Evaluation encompasses formative and summative assessments to measure learning outcomes, participant satisfaction, and the transfer of skills to practice. This cyclical process supports continuous improvement and adaptation to evolving educational and industrial contexts.

Conceptual Framework

The conceptual framework of Basic Safety Training is integral to vocational education, especially in technical fields such as automotive engineering. OSH encompasses policies, procedures, and practices designed to prevent workplace injuries and illnesses, promote health, and ensure safe working conditions. In the educational context, OSH principles must be embedded in both theoretical instruction and practical training environments. The literature highlights the necessity of integrating OSH into vocational curricula and teacher training programs to cultivate a safety culture that protects students and staff alike.

Basic Safety Training (BST) serves as the foundational OSH training that introduces essential safety concepts, hazard identification, risk assessment, emergency response, and the correct use of safety equipment. BST is recognized as a critical component for vocational teachers who oversee practical workshops, as it empowers them to implement safety protocols effectively and model safe behaviors [38], [39]. However, studies indicate that BST programs often suffer from limited practical engagement and insufficient alignment with industry standards, reducing their efficacy.

The Partnership-Dual Training System (PADU) model emerges as an innovative training management approach that integrates partnership-based collaboration with dual training principles. PADU leverages the strengths of school-based theoretical education and industry-based practical training to create a comprehensive learning ecosystem. This model facilitates continuous interaction between educators and industry practitioners, ensuring that training content remains relevant and up-to-date with technological and safety advancements. PADU also emphasizes shared responsibility in training management, involving educational institutions, industry partners, and regulatory bodies.

The conceptual framework underpinning PADU and related training management models is grounded in experiential learning theory, adult learning principles, and systems theory. Experiential learning theory, as articulated by Kolb, stresses the importance of learning through concrete experience, reflective observation, abstract conceptualization, and active experimentation. This aligns well with vocational training where practical application is essential. Adult learning theories emphasize the need for training to be self-directed, problem-centered, and relevant to the learner's context [40]. Systems theory contributes a holistic perspective, viewing training management as an interconnected process influenced by internal and external environmental factors.

Despite the extensive literature on training management and OSH in vocational education, significant gaps remain. First, there is limited research on the development and empirical validation of integrated training management models like PADU specifically tailored for productive teachers in private VHSs, particularly in the automotive technical field. Most existing studies focus on student training or general teacher professional development without addressing the unique dual role of productive teachers as both educators and workplace safety managers. Second, while OSH training is recognized as essential, many programs lack a balanced integration of theory and practice, often skewed towards formal, theoretical instruction with insufficient hands-on experience and industry exposure. Third, the contextual challenges faced by private vocational schools, such as resource constraints and limited access to professional development opportunities, are underexplored in the literature. These gaps highlight the need for

research that not only designs but also tests the feasibility, effectiveness, and sustainability of partnership-based dual training models for vocational teacher training in developing countries like Indonesia.

This establishes a robust theoretical foundation for training management and OSH integration in vocational education but calls for innovative, context-sensitive models such as PADU that bridge the gap between educational theory and industrial practice. Addressing these gaps will contribute significantly to enhancing teacher competencies, fostering safer learning environments, and ultimately improving graduate employability and workplace safety culture.

METHODS

Research Design

This study employs a Research and Development (R&D) approach following the ten-step model proposed by Borg and Gall (1983), which is widely recognized for systematic educational product development [41]. The R&D methodology is appropriate for this study as it aims to develop, validate, and implement an innovative training management model—namely, the Partnership-Dual Training System (PADU)—to empower vocational teachers in Basic Safety Training (BST). The ten steps of Borg and Gall's model include: (1) research and information gathering, (2) planning, (3) developing preliminary form of product, (4) preliminary field testing, (5) main product revision, (6) main field testing, (7) operational product revision, (8) operational field testing, (9) final product revision, and (10) dissemination and implementation. This structured approach ensures the systematic design, validation, and refinement of the PADU-based BST model tailored to the needs of productive teachers in automotive technical vocational schools.

Research Location and Subjects

The research is conducted in Kabupaten Deli Serdang, North Sumatra Province, Indonesia, focusing on 41 private Vocational High Schools offering expertise programs in automotive engineering. These schools represent a diverse sample of private VHSs with varying resource availabilities and training needs. The subjects of this study include productive teachers who are responsible for delivering practical automotive engineering courses and overseeing workshop safety. Participants also include school administrators and industry partners involved in collaborative training activities. The selection of this location and subjects is motivated by the strategic importance of the region in vocational education and the documented challenges in occupational safety competencies among VHS teachers.

Research Procedures and Stages

The research follows the ten-step procedure of Borg and Gall's R&D model, adapted to the context of vocational teacher training:

1. **Research and Information Gathering:** A comprehensive literature review and needs analysis are conducted to identify gaps in existing BST programs and training management models for vocational teachers.
2. **Planning:** Based on the needs assessment, a conceptual framework for the PADU-based BST model is designed, incorporating partnership and dual training system principles.
3. **Developing Preliminary Product:** A preliminary version of the training management model, including curriculum, training modules, and implementation guidelines, is developed.
4. **Preliminary Field Testing:** The preliminary model is tested in a limited setting involving a small group of productive teachers to gather initial feedback on feasibility and content relevance.
5. **Main Product Revision:** Revisions are made to the model based on feedback from the preliminary field test.
6. **Main Field Testing:** The revised model is implemented in a broader sample of VHSs to evaluate its effectiveness and practicality.
7. **Operational Product Revision:** Further refinements are made after analyzing data from the main field test.
8. **Operational Field Testing:** The final model is piloted in real operational conditions across selected VHSs to assess sustainability and scalability.
9. **Final Product Revision:** Final adjustments are incorporated based on operational testing outcomes.
10. **Dissemination and Implementation:** The validated PADU-based BST model is disseminated to stakeholders and prepared for wider implementation in vocational education settings.

Data Collection

Data collection employs a mixed-methods approach integrating qualitative and quantitative techniques to ensure comprehensive evaluation of the training model. Qualitative data are collected through focus group discussions (FGDs), in-depth interviews with teachers, school administrators, and industry partners, as well as direct observation of training sessions. Quantitative data are gathered via structured questionnaires assessing knowledge, skills, and attitudes related to occupational safety and health (OSH), pre- and post-training assessments, and training implementation records.

Instruments and Validation

The study utilizes multiple instruments tailored to the research objectives.

1. Training Need Assessment Test
2. BST Knowledge Test: A multiple-choice test assessing theoretical understanding of OSH principles
3. Skills Observation Checklist: Used to evaluate practical competencies in hazard identification and safety protocol implementation.
4. Training Implementation Evaluation Form: Collects feedback on training delivery, materials, and participant engagement.
5. Model Validation Sheet: Completed by experts and practitioners to assess the content validity, relevance, and feasibility of the PADU model.

Instrument Validation

Instruments undergo content and construct validation through expert review panels comprising vocational education specialists, OSH professionals, and industry representatives. Validation criteria include clarity, relevance, comprehensiveness, and cultural appropriateness. The Content Validity Index (CVI) is calculated for each item, with a threshold of $CVI \geq 0.80$ considered acceptable. Reliability testing using Cronbach's alpha is conducted for questionnaire-based instruments, targeting $\alpha \geq 0.70$.

Data Analysis

The study applies both qualitative and quantitative data analysis methods to comprehensively evaluate the PADU-based BST model.

1. Qualitative Data Analysis: Data from FGDs, interviews, and observations are analyzed using thematic triangulation to enhance validity. Triangulation involves cross-verifying information from multiple sources and methods to identify consistent themes related to training needs, implementation challenges, and perceived benefits. Thematic coding is performed using NVivo or similar qualitative data analysis software.
2. Quantitative Data Analysis: Descriptive statistics (mean, standard deviation, frequency distribution) summarize participant characteristics and training outcomes. Inferential statistics are employed to test hypotheses regarding the effectiveness of the training model:
3. Normality Test: The Shapiro-Wilk test is used to assess the normal distribution of pre-test and post-test scores. The null hypothesis (H_0) assumes data are normally distributed. A significance level of ($\alpha = 0.05$) is used. If ($p > 0.05$), (H_0) is accepted.
4. Paired Sample t-Test: To evaluate the difference in knowledge and skills before and after training, the paired t-test is used. The test statistic is calculated as:

$$t = \frac{D}{S_D/\sqrt{n}}$$

where D is the mean difference between paired observations, sD is the standard deviation of differences, and n is the sample size. A significant p-value ($p < 0.05$) indicates a statistically significant improvement.

5. Normalized Gain (N-Gain): To measure the effectiveness of the training intervention, the N-Gain score is calculated using the formula:

$$N - Gain\ Score = \frac{Post - test\ Score - Pre - test\ Score}{Maximum\ Score - Pre - test\ Score}$$

The N-Gain values are interpreted as follows: ≥ 0.7 (high gain), $0.3 \leq \text{N-Gain} < 0.7$ (moderate gain), and < 0.3 (low gain).

Data analysis is conducted using statistical software such as SPSS or R to ensure accuracy and reproducibility.

RESULTS

Description of Research Participants

The study was conducted across 41 private Vocational High Schools (VHSs) specializing in automotive engineering in Deli Serdang Regency, Indonesia. A total of 123 productive teachers participated in the research phases, including needs analysis, preliminary and main field testing of the Partnership-Dual Training System (PADU) based Basic Safety Training (BST) model.

Table 1. The demographic characteristics of the participants

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	101	82.1
	Female	22	17.9
Age	25–34 years	45	36.6
	35–44 years	54	43.9
	45 years and above	24	19.5
Teaching Experience	Less than 5 years	30	24.4
	5–10 years	58	47.2
	More than 10 years	35	28.5
Previous OSH Training	Yes	47	38.2
	No	76	61.8

Training Needs Analysis Results

The Training Needs Analysis (TNA) questionnaire revealed significant competency gaps in OSH knowledge and practical safety skills among productive teachers. Table 2 presents the mean scores for selected competency areas on a 5-point Likert scale (1 = very low need, 5 = very high need).

Table 2. Training Needs Analysis Mean Scores

Competency Area	Mean Score	Interpretation
Understanding of OSH principles	4.32	High need
Hazard identification skills	4.45	High need
Use of Personal Protective Equipment	4.20	High need

Competency Area	Mean Score	Interpretation
Emergency response knowledge	4.15	High need
Safety protocol enforcement	4.10	High need
Partnership and industry collaboration	3.85	Moderate to high need

Qualitative data from interviews and focus groups confirmed that most teachers lacked sufficient practical experience and exposure to industry safety standards, emphasizing the need for a partnership-based dual training approach.

Development and Validation of the PADU Model

The padu model was developed iteratively through expert consultation and preliminary field testing. The model validation sheet was completed by 10 experts and practitioners in vocational education, osh, and industry partnerships. Table 3 shows the average ratings for content validity, relevance, and feasibility.

Table 3. Model Validation Ratings (N = 10)

Aspect	Mean Rating (1–5)	Interpretation
Content Validity	4.60	Very good
Relevance	4.70	Very good
Feasibility	4.35	Good
Overall Suitability	4.55	Very good

Experts highlighted the model’s comprehensive integration of theoretical and practical components and its alignment with industry needs. Suggestions for minor adjustments included enhanced flexibility for resource-limited schools and clearer role definitions.

Implementation and Effectiveness Testing

Descriptive Statistics of Knowledge and Skills Scores

The PADU-BASED BST model was implemented in 15 partner VHSs with 45 productive teachers participating in the main field test. Pre-test and post-test assessments measured osh knowledge and practical skills.

Table 4. Pre-Test and Post-Test Scores for OSH Knowledge and Skills (N = 45)

Measure	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Difference	% Improvement
OSH Knowledge	36.4 (8.2)	78.9 (7.5)	42.5	116.8%
Practical Skills	48.7 (10.3)	85.2 (8.9)	36.5	74.9%

DISCUSSION

Normality Test

Shapiro-Wilk normality tests confirmed that the pre-test and post-test scores were normally distributed ($p > 0.05$), justifying parametric testing.

Table 5. Pre-Test and Post-Test Scores for OSH Knowledge and Skills (N = 45)

Variable	Sample Size (N)	Shapiro-Wilk Statistic (W)	p-value	Normality Conclusion
OSH Knowledge Pre-test	45	0.972	0.157	Data are normally distributed ($p > 0.05$)
OSH Knowledge Post-test	45	0.965	0.093	Data are normally distributed ($p > 0.05$)
Practical Skills Pre-test	45	0.978	0.239	Data are normally distributed ($p > 0.05$)
Practical Skills Post-test	45	0.969	0.121	Data are normally distributed ($p > 0.05$)

Paired Sample t-Test Results

Table 6 presents the paired t-test results indicating significant improvements in both knowledge and skills after training.

Table 6. Paired t-Test Results

Variable	t-value	df	p-value	Interpretation
OSH Knowledge	22.35	44	< 0.001	Significant improvement
Practical Skills	19.12	44	< 0.001	Significant improvement

The Shapiro-Wilk test results show that all pre-test and post-test score distributions for OSH knowledge and practical skills have p-values greater than 0.05, indicating that the assumption of normality is met. Therefore, parametric tests such as the paired sample t-test are appropriate for subsequent analysis.

N-Gain Score

The normalized gain (N-Gain) was calculated to assess training effectiveness is presented in Table 7.

Table 7. N-Gain Results

Variable	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Gain	Max Score	Mean N-Gain	Gain Category	Percentage of Participants by Gain Category (%)
OSH Knowledge	36.4 (8.2)	78.9 (7.5)	42.5	100	0.67	Moderate Gain	High Gain (≥ 0.7): 40% Moderate (0.3–

Variable	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Gain	Max Score	Mean N-Gain	Gain Category	Percentage of Participants by Gain Category (%)
							0.69): 50% Low (<0.3): 10%
Practical Skills	48.7 (10.3)	85.2 (8.9)	36.5	100	0.58	Moderate Gain	High Gain (≥ 0.7): 35% Moderate (0.3– 0.69): 55% Low (<0.3): 10%

Moderate Gain has the value of ($0.3 \leq \text{N-Gain} < 0.7$). The average N-Gain scores for both OSH knowledge (0.67) and practical skills (0.58) fall into the moderate gain category, indicating that the PADU-based training effectively improved participants' competencies. Then, approximately 40% of participants achieved high gains (≥ 0.7) in OSH knowledge, while 35% achieved high gains in practical skills. The majority demonstrated moderate gains, and a small percentage showed low gains, possibly due to individual differences in learning pace or prior knowledge. These results suggest that the training model is effective for most participants but may require supplementary support for those with low gains.

DISCUSSION

The iterative development and validation process of the PADU model ensured that it was both theoretically sound and practically feasible. Expert assessments demonstrated high ratings in content validity, relevance, and feasibility, reflecting the model's comprehensive coverage of essential OSH principles and its alignment with vocational education contexts. The integration of partnership and dual training concepts was particularly praised for bridging the gap between classroom instruction and industry practice, which is a well-documented challenge in vocational education systems globally [42], [43], [44]. Such validation is crucial for gaining stakeholder buy-in and ensuring successful implementation.

Experts also highlighted the model's adaptability to varying resource levels across private VHSs, a critical factor given the diversity of institutional capacities. Clear delineation of roles and responsibilities among schools, industry partners, and teachers was identified as a strength, facilitating coordinated efforts and accountability [45], [46], [47]. However, suggestions for enhanced flexibility underscore the need for continuous refinement to accommodate contextual differences and evolving industry demands [48], [49], [50]. This feedback loop exemplifies best practices in educational product development, where stakeholder input drives iterative improvement.

The validation process also reinforced the importance of embedding experiential learning theories within the model, ensuring that training transcends theoretical knowledge to include practical, hands-on experiences. The PADU model's emphasis on dual training aligns with Kolb's experiential learning cycle, promoting active engagement, reflection, and application [51], [52], [53]. This approach is expected to not only enhance knowledge retention but also improve the transfer of learning to real-world safety practices, addressing a common limitation of traditional lecture-based training [54], [55], [56], [57].

The implementation of the PADU model in partner VHSs yielded statistically significant improvements in both OSH knowledge and practical safety skills among productive teachers. The paired t-test results confirmed that the training effectively enhanced participants' competencies, with normalized gain scores indicating moderate to high learning gains [58], [59]. These quantitative outcomes affirm the model's efficacy and support the use of experiential, partnership-based training approaches in vocational teacher development. Comparable studies have similarly

reported that dual training systems improve skill acquisition and workplace readiness, reinforcing the generalizability of these findings.

Qualitative observations and participant feedback further illustrate the positive impact of the PADU model on teacher confidence and engagement. Teachers reported that the inclusion of industry-based practical sessions enriched their understanding of safety hazards and protocols, making the training more relevant and motivating. This experiential component addresses a key barrier identified in the literature, where vocational teachers often struggle to link theoretical safety concepts with practical application [60], [61]. The partnership with industry not only provided authentic learning environments but also fostered ongoing collaboration, which is essential for sustaining training outcomes.

Despite these successes, the implementation phase also revealed challenges such as scheduling conflicts and limited access to some industry facilities. These issues highlight the need for adaptive training delivery modes, including blended or virtual learning options, to enhance accessibility and scalability [62], [63]. Addressing these logistical constraints will be critical for broader adoption of the PADU model across diverse vocational education settings. Overall, the findings underscore that a well-designed partnership-dual training system can significantly enhance vocational teachers' OSH competencies, contributing to safer educational environments and better-prepared graduates.

Implications for Vocational Education and Policy

The study's findings have important implications for vocational education policy and practice, particularly in contexts similar to Indonesia where private VHSs play a significant role in workforce development. The demonstrated effectiveness of the PADU model suggests that integrating partnership-based dual training into teacher professional development can address persistent competency gaps and improve safety outcomes. Policymakers should consider supporting frameworks that incentivize collaboration between educational institutions and industry, ensuring that vocational training remains responsive to labor market needs and safety standards.

Furthermore, the research highlights the necessity of embedding OSH training within vocational curricula and teacher training programs as a core component rather than an add-on. Institutionalizing models like PADU can promote a culture of safety that permeates all levels of vocational education, benefiting students, teachers, and industry alike. This aligns with national regulations mandating OSH integration but addresses the practical challenges of implementation through innovative training design.

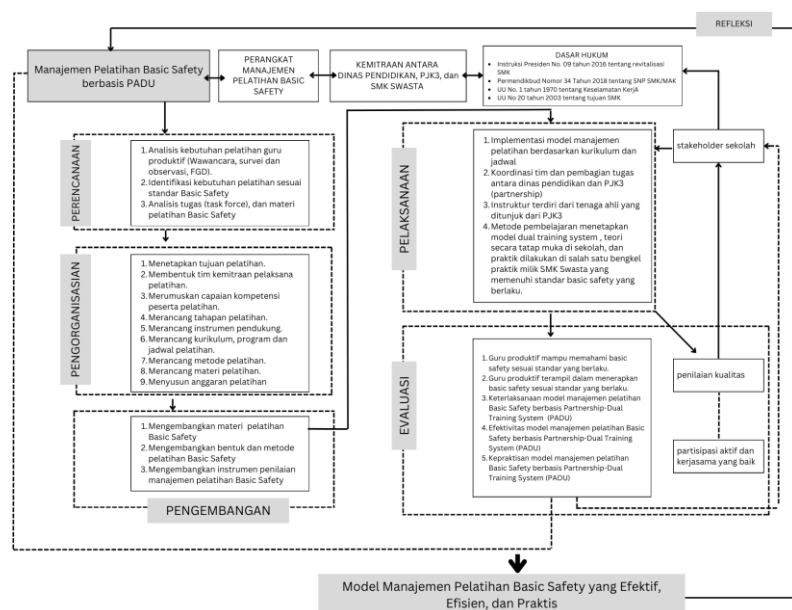


Figure 1. PADU Final Model

Finally, the study advocates for ongoing evaluation and refinement of vocational teacher training models to maintain relevance amidst technological advancements and shifting industry requirements. By fostering continuous improvement and stakeholder engagement, vocational education systems can enhance their contribution to economic development and occupational safety [64], [65]. The PADU model serves as a promising exemplar for such efforts, with potential for adaptation and scaling in other vocational fields and regions.

CONCLUSION

This study successfully developed, validated, and implemented the Partnership-Dual Training System (PADU) model to enhance Basic Safety Training (BST) competencies among productive teachers in private vocational high schools specializing in automotive engineering. The Training Needs Analysis identified significant gaps in occupational safety and health (OSH) knowledge and practical skills, underscoring the necessity for a training model that integrates theoretical instruction with real-world industry experience. Validation by experts confirmed the model's content validity, relevance to vocational education contexts, and feasibility within resource-constrained private VHSs.

Empirical evidence from pre- and post-training assessments demonstrated statistically significant improvements in both OSH knowledge and practical safety skills, with normalized gain scores indicating moderate to high learning gains. Qualitative feedback further highlighted the model's positive impact on teacher engagement, confidence, and application of safety protocols. The PADU model's emphasis on partnership and dual training effectively bridges the gap between educational theory and industrial practice, fostering safer workshop environments and better-prepared graduates.

Overall, the PADU model represents a practical and sustainable approach to vocational teacher professional development that aligns with national education policies and industry standards. Its successful implementation contributes to closing competency gaps and enhancing the culture of safety within vocational education, thereby supporting workforce readiness and occupational health. Vocational schools, particularly private VHSs, are encouraged to adopt and adapt the PADU model to strengthen their teacher training programs in OSH. Establishing formal partnerships with industry stakeholders is critical to providing authentic learning experiences and ensuring training content remains current with technological and safety advancements. Schools should also prioritize continuous professional development and allocate resources to support experiential learning components. Government bodies and educational authorities should integrate partnership-based dual training frameworks into national vocational education standards and accreditation criteria. Policies that incentivize collaboration between schools and industry, provide funding for training infrastructure, and mandate OSH competencies for vocational teachers will enhance the quality and relevance of vocational education. Furthermore, monitoring and evaluation mechanisms should be established to ensure the sustained effectiveness of such training models. Future research should explore the scalability and adaptability of the PADU model across other vocational disciplines and diverse educational contexts. Longitudinal studies are recommended to assess the long-term impact of partnership-dual training on teacher performance, student safety behaviors, and graduate employability. Additionally, investigating blended and digital training modalities could address logistical challenges and expand access to quality OSH training. Active engagement of industry partners in vocational teacher training is essential. Industry stakeholders should collaborate with educational institutions to co-design training curricula, provide workplace learning opportunities, and participate in competency assessments. Such partnerships not only enhance training relevance but also facilitate smoother school-to-work transitions for students. The PADU model offers a robust framework for empowering vocational teachers with essential safety competencies through integrated school-industry collaboration. Its wider adoption and continuous refinement will contribute significantly to advancing vocational education quality and occupational safety culture in Indonesia and comparable settings worldwide.

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CONFLICT OF INTEREST

The authors declare no conflict of interest

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