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Practice-Based Training Model for Occupational Safety in Vocational Welding Workshops

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Abstract*—Welding workshops in vocational education are high-risk environments where students are exposed to hazards such as heat, ultraviolet radiation, fumes, and the risk of mechanical injury. In Islamic boarding school-based vocational programs, these risks are exacerbated by limited facilities and weak safety management systems, underscoring the urgency of structured Occupational Safety and Health (OHS) training. This study addressed this research gap by implementing a practice-based OHS training model in Islamic boarding school welding workshops, designed through five integrated stages: socialisation, training, SOP implementation, mentoring, and evaluation. This methodology combines a participatory approach with quantitative and qualitative evaluation, using pre/post tests, observation sheets, and interviews to measure knowledge, behaviour, and cultural change. Results showed significant improvements across ten OHS categories, with the average score increasing from 61.1% to 89.2%. The largest improvements were observed in knowledge of PPE functions (53.3%) and commitment to a safety culture (51.7%), confirming that practice-based training effectively translates awareness into disciplined behaviour. Practice-based OHS training can be successfully adapted to vocational Islamic boarding schools, fostering technical competence and a sustainable safety culture. This model offers insights that can be integrated into engineering curricula, supporting broader efforts to promote decent work and long-term occupational health protection.*

***Keywords*—** *Occupational Safety and Health, Vocational Education, Welding Workshop, Practice Based Training, Safety Culture, Pesantren.*

I. INTRODUCTION

Welding workshops are among the most hazardous environments in vocational education, exposing students to risks such as excessive heat, ultraviolet radiation, toxic fumes, and mechanical injuries. Without adequate safety procedures, these risks not only endanger health but also disrupt the learning process, reducing the effectiveness of vocational training programs[1]. Therefore, integrating Occupational Safety and Health (OSH) principles into vocational curricula is crucial to ensure that students acquire technical skills while simultaneously developing safe work behaviours[2].

In Indonesia, Islamic boarding schools are increasingly adopting vocational programs to prepare students for the workforce. Welding workshops in these institutions provide valuable opportunities for hands-on learning, but they also highlight critical gaps in safety practices. Observations show that students frequently neglect personal protective equipment (PPE), inconsistently adhere to standard operating procedures (SOPs), and show limited preparedness for emergencies [3][4][5]. These findings align with previous studies in vocational schools, which emphasised that safety management systems remain underdeveloped and require structured interventions [6]. Addressing this gap is crucial, as vocational education plays a central role in preparing young workers for industrial environments where safety compliance is non-negotiable.

Vocational education systems have long emphasised integrating safety standards into technical training. A dual system that combines classroom learning with industrial practice ensures that safety procedures are embedded in daily work. Integration of safety modules into the engineering curriculum and the recognition of safety culture as a core competency for graduates have been widely discussed [2][7]. These models demonstrate that effective vocational education must balance skills acquisition with occupational safety. However, in developing countries like Indonesia, structured OSH training models are still limited, particularly in Islamic boarding school-based vocational programs[3][6].

First, welding-related hazards demand OSH competence that covers immediate accident prevention and long-term health protection [7][8]. Second, vocational OSH effectiveness depends on the formation of a safety culture through repeated practice, supervision, and institutionally reinforced SOP-based routines[9][10]. Third, practice-based training can be strengthened through structured modules and digital media such as e-modules, simulations, and VR, but these should be integrated with mentoring and compliance monitoring to convert awareness into disciplined behaviour [11]. This synthesis directly supports an experimental evaluation framework in vocational welding workshops that measures OSH knowledge gains, PPE/SOP compliance, and safety culture indicators through a structured, replicable intervention[12].

This study aims to address the identified gap by implementing occupational safety procedures in a welding workshop at an Islamic boarding school in Indonesia. Using a participatory, practice-based approach including counselling, demonstrations, simulations, and mentoring this study evaluates the effectiveness of OSH training in improving safety literacy, compliance, and preparedness. The study's contribution lies in providing empirical evidence on how structured, practice-based safety training can translate awareness into disciplined behaviour and establish a replicable model for vocational education. Beyond its local relevance, these findings offer insights for global vocational education institutions seeking to integrate safety culture into engineering

curricula, thereby supporting sustainable development in vocational training.

II. Literature Review

Occupational Safety and Health (OHS) is a key component of vocational education, particularly in high-risk engineering fields such as welding[5]. The OHS discourse increasingly emphasises the role of training ecosystems, digital tools, and risk-based management in reducing workplace incidents and building a sustainable safety culture across various sectors[13].

A. OHS Risks in Welding and the Importance of Safety Competence

Welding activities are consistently classified as high-risk operations due to exposure to thermal hazards, ultraviolet and infrared radiation, electric current, welding fumes, and ergonomic stress[14][2]. Occupational accidents and health problems among welders are closely linked to inadequate safety procedures and inconsistent use of personal protective equipment (PPE)[15]. These risks are not unique to industrial production environments; they are also prevalent in small scale workshops and vocational workshops, where safety management systems are often informal or poorly enforced[16].

B. Safety Culture and Safety Performance as a Framework for Vocational Workshops

Recent OHS research emphasises safety culture as a key determinant of safety performance. Safety culture extends beyond formal regulations to encompass shared values, attitudes, and behaviours related to workplace safety. Vocational workshops with stronger safety cultures demonstrate higher levels of procedural compliance and lower incidences of unsafe behaviour. Therefore, safety performance is increasingly measured through observable indicators such as compliance with standard operating procedures (SOPs), use of PPE, and disciplined work practices[17][18].

C. Practice-Based Training, Mentoring, and Behavior Change Mechanisms

Practice-based training is widely recognised as an effective approach for translating safety knowledge into good behaviour. Safety learning follows a behavioural pathway in which structured instruction enhances safety knowledge, which, in turn, influences procedural compliance and PPE use[19]. Direct mentoring and supervision during practical activities further reinforce safe behaviour by providing immediate feedback and positive actions. Safety behaviour changes are more sustainable when safety procedures are embedded in daily practice routines rather than delivered through one-off instructional sessions[20].

D. Occupational Health and Safety Learning Media, Modules, and Technology Training

The development of structured occupational health and safety learning media, including safety modules, e-learning systems, and simulation-based training for vocational contexts[20]. Designed occupational health and safety modules, evaluated using a pre-post assessment framework, can improve safety outcomes[21]. Furthermore, simulation-based training technology is gaining traction because it allows learners to experience hazards without risk. However, technology-enabled training alone is insufficient to ensure sustainable safety behaviours unless combined with procedural enforcement, supervision, and implementation in a real-world workshop.

E. PPE Awareness and Compliance as Measurable Outcomes

PPE awareness and compliance are among the indicators commonly used to evaluate OHS effectiveness because they can directly prevent accidents[21][22]. Experimental studies on PPE use provide structured safety, especially when clear SOPs are in place and supported by PPE availability. These findings suggest that PPE compliance can contribute to broader safety during.

III. Methodology

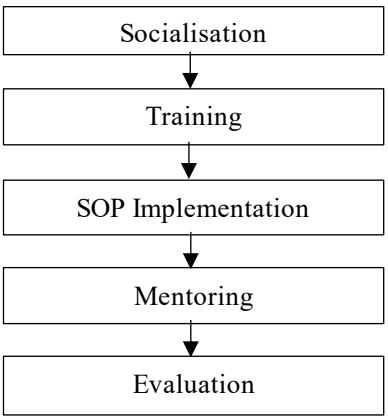

Fig. 1. Workflow of Occupational Safety Procedure Implementation in a Welding Workshop

Community service activity aimed to implement occupational safety and health (OSH) procedures in a participatory manner within the welding workshop of Pesantren Quantum. Both students and instructors acted as active subjects throughout the process. The implementation method consisted of five integrated stages[23][12][24]:

1. Socialisation: The team introduced basic OSH concepts and potential workplace hazards through presentations and interactive discussions. The material covered types of welding risks, the importance of personal protective equipment (PPE), and the consequences of workplace accidents on health and learning. This stage provided students and instructors with a foundational understanding of safety principles.
2. Training: Students participated in demonstrations of proper PPE usage, simulations of safe welding practices, and introductions to correct welding procedures. Training was conducted directly in the workshop under supervision, enabling students to experience real applications of OSH principles. This stage emphasised practical skills and reinforced safety awareness through hands-on practice.
3. SOP Implementation The team collaborated with instructors to design and implement Standard Operating Procedures (SOPs) for welding safety, adapted to the specific conditions of the pesantren workshop. The SOPs included work preparation, PPE usage, equipment operation, and

post-welding handling. Safety posters were installed in the workshop to serve as visual reminders of daily compliance.

4. Mentoring: Continuous mentoring was provided throughout the welding practice sessions. The team offered direct feedback on students' work behaviour and supported instructors in monitoring consistent application of safety procedures. This stage ensured that OSH practices were not only introduced but also internalised as habitual work behaviour.
5. Evaluation measured the program's effectiveness using pre-test and post-test questionnaires, direct observations, and interviews. Indicators included improvements in knowledge, attitudes, and behaviours related to OSH, the establishment of a safety culture in the workshop, and social and economic impacts such as enhanced work quality and student readiness for industrial employment. Behavioural changes were assessed through observation sheets focused on PPE use and SOP compliance, while cultural and economic impacts were explored through qualitative interviews and descriptive analysis.

The indicators used to calculate the percentage increase in students' knowledge and behavioural compliance levels are consistent. The percentage increase is determined by comparing the average pre-test and post-test scores for PPE and SOP use. The percentage increase in students' occupational safety knowledge was calculated using the following formula:

$$P = \frac{(X_{post} - X_{pre})}{X_{pre}} x100\%$$

where X_{pre} represents the average pre-test score, X_{post} denotes the average post-test score, and P indicates the percentage increase.

This formula was applied to each indicator of occupational safety and health (OSH), including PPE usage, SOP compliance, emergency response, and hazard identification. By employing this calculation, the study was able to quantify the effectiveness of the intervention in improving students' knowledge and safety practices.

The compliance rate of students in applying occupational safety procedures was calculated using the following formula:

$$C = \frac{n_{compliant}}{N} x100\%$$

where $n_{compliant}$ represents the number of students who consistently adhered to the safety procedures, N denotes the total number of students observed, and C indicates the compliance rate expressed as a percentage.

This formula was applied to evaluate behavioral changes during welding practice, specifically focusing on the consistent use of personal protective equipment (PPE) and adherence to standard operating procedures (SOPs). By quantifying compliance in this manner, the study was able to measure the effectiveness of mentoring and supervision in embedding safety practices into daily workshop activities.

The reliability of the questionnaire instrument was tested using Cronbach's Alpha, which is widely applied to measure internal consistency. The formula is expressed as follows:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum \sigma_i^2}{\sigma_{total}^2}\right)$$

where k represents the total number of questionnaire items, σ_i^2 denotes the variance of each individual item, and σ_{total}^2 refers to the total variance of the overall score.

A Cronbach's Alpha value greater than 0.70 was considered acceptable, indicating that the instrument used in this study was reliable for measuring students' knowledge, attitudes, and behaviors related to occupational safety and health (OSH). By applying this formula, the study ensured that the evaluation results were based on a valid and consistent measurement tool.

The program's success was determined by increased OSH knowledge scores, improved safety awareness, disciplined work behavior, and stronger institutional commitment to sustaining safety procedures. These outcomes provided evidence of the effectiveness of the practice-based training model in embedding occupational safety within vocational welding education.

IV. Results

The implementation of occupational safety and health (OSH) procedures in the welding workshop at Pesantren Quantum has led to positive changes at the individual, community, and institutional levels. The program improved students' knowledge and awareness of welding risks and the importance of personal protective equipment (PPE). This was reflected in more disciplined behavior, with students consistently using welding helmets, protective glasses, gloves, and aprons during practice. Instructors also began enforcing stricter supervision of safety procedures. These changes contributed to the establishment of a safety-oriented work culture within the pesantren, which is expected to prepare students for future industrial employment.

The program's strengths lie in its participatory approach, the contextual design of OSH SOPs, and the provision of practical educational materials, such as safety posters. Identified weaknesses included the limited availability of standardized PPE and the lack of formally certified OSH instructors. The level of difficulty was moderate, particularly in habituating students to consistently use PPE and follow SOPs. The production of educational media required adaptation to the simple workshop conditions. However, future opportunities remain open, including advanced training, improved facilities, and replication of the pesantren-based OSH training model in other institutions.

Fig. 2. Personal Protective Equipment (PPE) Used in Training:

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This figure shows the range of PPE used during training sessions, including helmets, safety shoes, earmuffs, respirators, disposable masks, protective glasses, tinted goggles, gloves, and reflective vests. The diversity of equipment reflects efforts to protect participants from welding hazards, including heat, sparks, noise, dust, fumes, and mechanical risks.

Fig. 3. Welding Workshop Training with OSH Supervision.

This figure illustrates the workshop environment during welding practice, with students actively engaged under instructor supervision. Safety mentoring was conducted through direct monitoring of PPE usage, workspace arrangement, and safe work procedures.

TABLE 1. Improvement in OSH Understanding Among Students

Category	Pre-test (%)	Post-test (%)	Gain (%)
Basic OSH Concepts	62	88	41.9%
Hazard Identification	65	90	38.5%
Knowledge of PPE Functions	60	92	53.3%
Correct Use of PPE	63	91	44.4%
SOP Compliance	66	89	34.8%
Emergency Response	58	87	50.0%
Workshop Cleanliness	61	90	47.5%
Safety Inspection	59	88	49.2%
Awareness of Long-term Risks	57	86	50.9%
Commitment to Safety Culture	60	91	51.7%
Overall Average	61.1	89.2	46.2%

Explanation of Table 1: improvement in OSH understanding. The table presents a comparison of pre-test and post-test scores across 10 categories of occupational safety and health (OSH) evaluation. Each category represents a specific dimension of safety knowledge, attitude, or behaviour. The Gain (%) column shows the relative increase, calculated as the difference between post-test and pre-test scores divided by the pre-test score, then multiplied by 100. All values are rounded to one decimal place for clarity.

1. Basic OSH Concepts (41.9%) Students initially scored 62%, indicating limited understanding of fundamental safety principles. After training, scores rose to 88%, reflecting a 41.9% improvement. This shows that the program successfully strengthened students' conceptual foundation of OSH.
2. Hazard Identification (38.5%) Pre-test results (65%) revealed moderate ability to recognize welding hazards. Post-test scores (90%) demonstrate a 38.5% gain, confirming that students became more capable of identifying risks in their work environment.
3. Knowledge of PPE Functions (53.3%) This category recorded the highest gain. Students' knowledge increased from 60% to 92%, a 53.3% improvement. The result highlights the effectiveness of practical demonstrations in teaching the importance and correct use of PPE.
4. Correct Use of PPE (44.4%) Scores improved from 63% to 91%, yielding a 44.4% gain. This indicates that students not only understood PPE functions but also learned to apply them correctly during welding practice.
5. SOP Compliance (34.8%) Compliance with standard operating procedures rose from 66% to 89%, a 34.8% gain. Although the increase is smaller compared to other categories, it reflects steady progress in embedding safe work routines.
6. Emergency Response (50.0%) Students' ability to respond to emergencies improved significantly, from 58% to 87%, a 50.0% gain. This demonstrates that simulations and mentoring effectively prepared them for unexpected situations.
7. Workshop Cleanliness (47.5%) Scores increased from 61% to 90%, a 47.5% gain. This shows that students became more disciplined in maintaining a clean and organized workspace, reducing potential hazards.
8. Safety Inspection (49.2%) Understanding of the importance of safety inspections rose from 59% to 88%, a 49.2% gain. Students began to recognize inspection as a routine practice rather than an optional task.
9. Awareness of Long-term Risks (50.9%) Awareness improved from 57% to 86%, a 50.9% gain. This indicates that students developed stronger concern for the long-term health impacts of welding exposure.
10. Commitment to Safety Culture (51.7%) Scores increased from 60% to 91%, a 51.7% gain. This reflects the establishment of a collective commitment to safe practices, marking a cultural shift within the workshop environment.

Overall Average (46.2%) Across all categories, the average pre-test score was 61.1%, while the post-test average reached 89.2%. The overall gain of 46.2% confirms that the practice-based training model was highly effective in improving both knowledge and behavior related to OSH

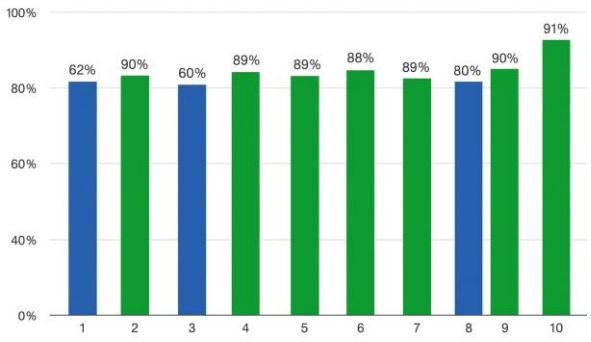

Fig. 4. Improvement in OSH Understanding Before and After Training.

Figure 4 illustrates improvements in students' understanding of occupational safety and health (OHS) across the 10

evaluation categories. In Category 1 (Basic OHS Concepts), the score increased from 62% before the training to 88% after. This indicates that the training successfully strengthened students' conceptual foundations, ensuring they understood the basic principles of workplace safety more comprehensively.

In Category 3 (Knowledge of PPE Functions), the score increased from 50% to 90%. This indicates improvement across all categories, increasing students' awareness of the types and functions of personal protective equipment.

In Category 8 (Safety Inspection), the score jumped from 30% to 86%. In Category 10 (Commitment to a Safety Culture), the score increased from 60% to 91%. These results confirm that the safety culture in the workshop environment demonstrates shared values among students and instructors.

V. Discussion

The results of this study demonstrate that a practice-based OSH training model implemented in a pesantren welding workshop can significantly improve students' safety knowledge, behavior, and cultural commitment. The quantitative data showed consistent gains across all ten evaluation categories, with final scores exceeding 86% in each domain. The most substantial improvements were observed in students' understanding of PPE functions (53.3%) and their commitment to safety culture (51.7%), indicating that the intervention not only enhanced technical literacy but also fostered long-term behavioral change.

These findings align with previous studies emphasizing the effectiveness of experiential learning in vocational safety education. Randyputra et al. (2021) highlighted that direct practice and mentoring are critical in embedding safety habits among students in technical environments. Similarly, Sayuti and Fauzi (2022) found that contextual SOPs and visual media significantly increased compliance in school-based workshops. The present study reinforces these conclusions by demonstrating that even in a modest pesantren setting, structured interventions can yield measurable improvements in safety outcomes.

Qualitative observations further support the quantitative results. Students reported increased confidence and discipline in using PPE, while instructors noted reduced resistance to safety protocols. The presence of visual aids such as posters and the use of direct supervision contributed to the normalization of safe practices. These elements are consistent with Ilyansyah's (2020) assertion that safety culture is best cultivated through repeated exposure, peer modeling, and institutional reinforcement.

VI. Conclusion

The implementation of occupational safety and health (OHS) training in the welding workshop at Quantum Islamic Boarding School has been effective in improving students' knowledge, attitudes, and practices regarding occupational safety. The intervention, structured through socialization, training, implementation of standard operating procedures (SOPs), mentoring, and evaluation, resulted in significant improvements across all assessment categories. Quantitative findings indicated that students' understanding increased from an average of 61.1% before the training to 89.2% after, with the greatest gains observed in knowledge of PPE function and commitment to a safety culture. Qualitative observations further confirmed these results, demonstrating greater discipline in PPE use, improved adherence to SOPs, and a stronger awareness of long-term occupational risks. The program's strengths lie in its participatory approach, SOP design, and use of educational media, which foster a sustainable safety culture within the Islamic boarding school environment. While the lack of certified OHS instructors has been identified, the program demonstrates that simple, hands-on training in a vocational setting can instill safety literacy and a commitment to a safety culture among students.

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