

OCCUPATIONAL AND SAFETY HEALTH (OSH) RISK ANALYSIS IN WELDING EDUCATION LABORATORIES ON STUDENT LEARNING OUTCOMES

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ABSTRACT

This study analyzes the relationship between Occupational Safety and Health (OSH) implementation in the welding laboratory and students' learning outcomes at SMK Negeri 10 Semarang. As a high-risk practical area, the welding lab requires strict OSH application to ensure safety, prevent accidents, and support effective learning. Using a quantitative descriptive approach, data were collected through observations, questionnaires, and documentation of student outcomes. The questionnaire, delivered via Google Form, contained 50 items on workplace risks, Personal Protective Equipment (PPE), and laboratory conditions. Results show risk identification scored 83%, likelihood analysis 84%, impact analysis 83%, and control measures 77%. These findings indicate that effective OSH practices positively influence students' concentration, motivation, and safety during practice. Correlation analysis further confirms OSH's impact on achievement. Risk Identification shows a significant positive correlation with learning outcomes ($r = 0.582$, $p = 0.001$), Probability/Likelihood has the strongest correlation ($r = 0.614$, $p = 0.000$), and Consequence/Severity also demonstrates a positive relationship ($r = 0.553$, $p = 0.002$). Existing Controls, while weaker ($r = 0.471$, $p = 0.012$), remain significant. These results highlight that students' awareness of risks, accident likelihood, and potential impacts directly contributes to higher practical scores, with average improvements of 5–10 points compared to classes with weaker OSH implementation. The study recommends reinforcing OSH protocols, providing regular training, and ensuring adequate safety facilities to enhance academic achievement and vocational welding skills.

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INTRODUCTION

Occupational safety and health (OSH) play a very vital role in the learning process, especially in laboratories that have high-risk potential, like welding labs (Ma'ruf dkk., 2024). This environment not only presents physical dangers such as welding sparks, heat radiation, and harmful gas fumes, but also risks of fire and injuries from heavy and sharp equipment. Therefore, applying OSH principles must be a top priority, starting with the use of complete personal protective equipment (PPE) such as welding helmets, heat-resistant gloves, safety glasses, and flame-resistant clothing

(Kursunoglu dkk., 2022). In addition, regular training on safety procedures, handling chemicals, and emergency steps should be provided to every student and teaching staff. By building awareness and OHS skills from the start, the welding lab not only becomes a safe place to learn, but also fosters a professional work culture that values safety as an integral part of every lab and experiment activity.

However, despite the general emphasis on OSH in vocational education, specific studies focusing on welding laboratories at the secondary vocational level remain limited. At SMK Negeri 10 Semarang, preliminary observations indicate fluctuations in students' practical scores and reports of minor incidents such as burns from sparks or discomfort due to inadequate ventilation. These local conditions highlight a research gap: while theoretical frameworks on OSH are well established, empirical evidence linking OSH implementation to student learning outcomes in this particular context is scarce.

The educational laboratory in the field of welding not only serves as a place for students to hone their technical skills through hands-on practice, but it also carries various potential hazards that can affect their health and safety (Yunus dkk., 2025). The welding process involves using high-voltage equipment and extreme temperatures, which, if not handled properly, can cause burns or electric shocks. Metal sparks that fly off during welding can injure the skin or eyes, while exposure to metal fumes, dust, and ultraviolet and infrared radiation can lead to respiratory problems, eye irritation, and even long-term health issues. Additionally, the risk of fire from hot sparks or flammable materials highlights the importance of strictly following safety procedures (Akano dkk., 2024). Therefore, managing a welding lab should pay attention to good ventilation design, the use of adequate personal protective equipment (PPE), and regular safety training, so that students can learn effectively while minimizing the potential risk of accidents and health hazards.

Applying occupational health and safety principles in educational laboratories isn't just about preventing accidents and work-related illnesses, it also significantly boosts the quality of learning (Deswati & Setyaningsih, 2024). By ensuring a safe lab environment, students and teachers can focus on experiments without worrying about potential physical, chemical, or biological hazards. Plus, a safe workspace helps build a culture of discipline and responsibility, strengthens understanding of scientific concepts, and improves students' practical skills through systematic and controlled lab practices. Implementing safety measures also encourages efficient use of equipment, reduces damage and interruptions in the learning process, creating a teaching and learning experience that's not only safe but also more productive, organized, and results-oriented (Mubita dkk., 2023).

A safe working environment plays a crucial role in supporting students' learning development (Dalimunthe dkk., 2024). When students are in a controlled environment with minimal risks, they can work with higher focus, increased confidence, and strong motivation to complete both practical and theoretical tasks. This condition allows students to internalize concepts more effectively, apply practical skills accurately, and achieve optimal learning outcomes. On the other hand, a high-risk or poorly controlled environment can cause psychological pressure, like anxiety and stress, which negatively affects concentration and information processing abilities (Derdowski & Mathisen, 2023). As a result, concept comprehension becomes partial, practical skills don't develop optimally, and the quality of learning achievements decreases. Therefore, creating and maintaining a safe work environment is not just about physical safety, but also about building a supportive, enjoyable, and conducive learning atmosphere for the academic and psychological growth of students (Dalimunthe dkk., 2024).

This study aims to analyze occupational health and safety risks in the welding laboratory at SMK Negeri 10 Semarang and examine their impact on student learning outcomes. By addressing the local gap, linking safety practices with fluctuations in student achievement, the research provides evidence-based recommendations for designing effective safety procedures and creating a conducive, safe, and productive learning environment.

METHOD

This study uses a descriptive approach, as stated by Rusandi & Rusli (2021), that descriptive research aims to describe an event or incident in a real, actual, and realistic way. In this context, the researcher describes the condition of the welding laboratory environment at SMK Negeri 10 Semarang scientifically based on findings during data collection. The research subjects involved 30 tenth-grade students of the Welding Engineering program, with data collected using a Google Form-based questionnaire consisting of 50 questions about workplace safety risks, use of Personal Protective Equipment (PPE), and the condition of the laboratory environment. The research instruments included a questionnaire for the independent variable on health and safety knowledge, as well as an observation sheet to assess the behavior in applying occupational health and safety practices (Maesaroh dkk., 2025).

In addition to these instruments, documentation of student learning outcomes was systematically extracted from two sources: (1) theoretical exam scores in welding engineering subjects, and (2) practical welding performance scores, assessed through standardized rubrics covering accuracy of technique, safety compliance, and product quality. These dual indicators ensure that the dependent variable, student achievement is transparently measured and directly comparable across respondents. The questionnaire was designed based on four main aspects, namely Risk Identification, Probability/Likelihood Analysis, Consequence/Severity Analysis, and Existing Controls. Each aspect is measured using a Likert scale (*Strongly Agree, Agree, Disagree, Strongly Disagree*). The data obtained are analyzed using quantitative descriptive techniques based on percentages, through stages of collection, grouping, interpretation, and drawing conclusions (Gevisa & Kurniati, 2024). Furthermore, to examine the relationship between OSH implementation and student achievement, the study employs parametric correlation tests (Pearson) when data meet normality assumptions, or non-parametric alternatives (Spearman's rho) when distributions are skewed. This dual analytic strategy ensures methodological rigor and provides valid insights into how occupational safety practices influence both theoretical and practical learning outcomes.

RESULT AND DISCUSSION

RESULT

Summary of Questionnaire Results

The questionnaire sheets that were distributed contained four answer choices: Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD). From distributing the questionnaire to 30 10th-grade students at SMK Negeri 10 Semarang, the results were as follows:

Table 1. Summary of Questionnaire Result

Assessment Aspects	SA	A	D	SD	Total
Risk Identification	12 (40%)	13 (43%)	3 (10%)	2 (7%)	30 (100%)
Probability/Likelihood	11 (37%)	14 (47%)	3 (10%)	2 (6%)	30 (100%)
Consequence/Severity	10 (33%)	15 (50%)	3 (10%)	2 (7%)	30 (100%)
Existing Controls	9 (30%)	14 (47%)	4 (13%)	3 (10%)	30 (100%)

Source: Student questionnaire results

From the presentation of the results above, the interpretation of the values is as follows:

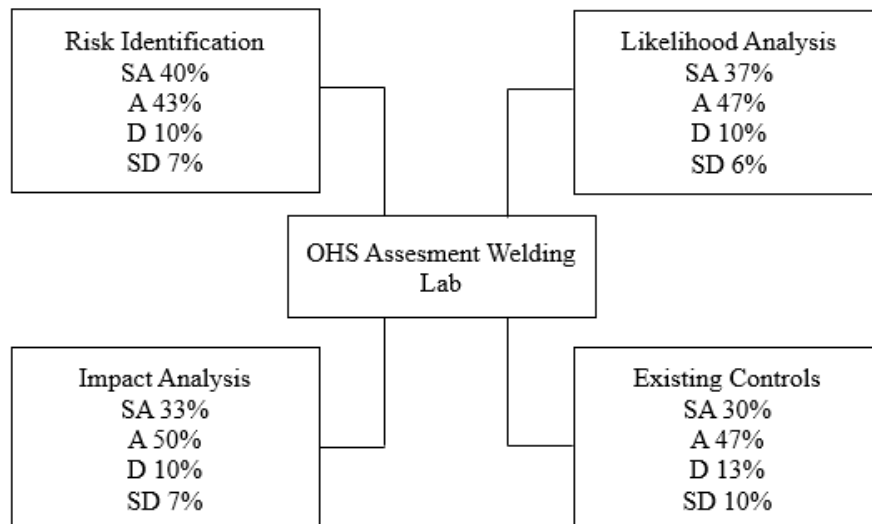
First, Risk Identification: The majority of students (83%) fall into the Agree and Strongly Agree categories, showing fairly high awareness of potential hazards in the laboratory.

Second, Possibility Analysis: Most students (84%) think the chance of an accident is pretty high, showing they're aware of work risks.

Third, Impact Analysis: 83% of respondents realize that accident impacts can be serious, so implementing occupational health and safety is considered important.

Fourth, Control: 77% of students think K3 control has been implemented, although 23% still feel that it's not fully applied.

Figure 1. Questionnaire Results Diagram



Source: Student questionnaire results

The next step is testing using a correlation test, to find out the influence of K3 on students' learning outcomes. The results of this test are shown in the table below;

Table 2. Correlations

Variables	Student Achievement	Risk Identification	Probability	Consequence	Controls	
Student Achievement	Pearson Correlation	1	.582**	.614**	.553**	.471*
	Sig. (2-tailed)	—	.001	.000	.002	.012
	N	30	30	30	30	30
Risk Identification	Pearson Correlation	.582**	1	.721**	.698**	.645**
Probability	Pearson Correlation	.614**	.721**	1	.734**	.662**
Consequence	Pearson Correlation	.553**	.698**	.734**	1	.671**
Controls	Pearson Correlation	.471*	.645**	.662**	.671**	1

Source: SPSS output from student questionnaires

From the data analysis above, we got the following findings:

Risk Identification shows a fairly strong positive correlation with students' learning achievement ($r = 0.582$, $p = 0.001$). This means that the higher the students' ability to identify risks, the better the practical scores they achieve.

Probability/Likelihood has the highest correlation ($r = 0.614$, $p = 0.000$). This confirms that students' awareness of the likelihood of accidents significantly contributes to improving learning outcomes.

Consequence/Severity also has a positive correlation ($r = 0.553$, $p = 0.002$). Students' understanding of the impact of accidents is related to increased motivation and caution, resulting in better practical scores.

Existing Controls shows a weaker positive correlation ($r = 0.471$, $p = 0.012$), but it's still significant. This indicates that implementing existing safety controls still affects learning achievement, even though it's not yet optimal.

The correlation test results showed that all aspects of OHS have a positive and significant relationship with student learning achievement. Risk Identification ($r = 0.582$, $p = 0.001$), Probability/Likelihood ($r = 0.614$, $p = 0.000$), and Consequence/Severity ($r = 0.553$, $p = 0.002$) proved to strongly contribute to higher practical scores. Meanwhile, Existing Controls ($r = 0.471$, $p = 0.012$) still have an effect, although it's weaker. These findings confirm that students' awareness of risks, probabilities, and accident impacts goes hand in hand with increased focus, motivation, and better performance (Dalimunthe dkk., 2024).

Mechanically, being disciplined in using Personal Protective Equipment (PPE) like welding helmets, heat-resistant gloves, and safety glasses has been shown to improve students' focus because they feel safe from sparks and radiation. This condition allows for more precise mechanical movements, so the quality of welding results improves. Additionally, optimizing air circulation in the practice room reduces exposure to metal fumes and harmful gases, which actually lowers respiratory problems and fatigue. This healthier work environment supports long-term concentration, strengthens technical accuracy, and ultimately boosts students' practical scores (Zulkarnain & Lestari, 2025). Therefore, implementing occupational safety and health (OSH) in the welding lab at SMK Negeri 10 Semarang not only serves as accident prevention but also becomes a key factor in achieving vocational skills optimally.

Identifying Potential Hazards in the Welding Laboratory

Based on observations and interviews at the welding laboratory at SMK Negeri 10 Semarang, there are various potential hazards that need serious attention to keep workers safe, including:

Mechanical hazards come from the risk of getting poked or cut by welding tools and the possibility of getting pinched by operating machines, so wearing physical protection like gloves and machine safety devices is highly recommended.

Figure 2. Welding Hand Equipment



Source: <https://www.industrialsafetyproducts.com/mcr-safety-4600-leather-welding-gloves/>

Thermal hazards often happen because of sparks or hot metal surfaces, which can cause burns; using face shields, heat-resistant aprons, and keeping an eye on material temperatures becomes important.

Figure 3. Welding Personal Protection



Source: <https://www.anakteknik.co.id/111834009372759470353/articles/>

The dangers of electricity can cause electric shocks, especially from damaged or poorly insulated wires or welding equipment, so regular checks and proper grounding are really important.

Figure 4. Electrical Hazard Potential



Source: <https://www.dreamstime.com/>

From an ergonomic perspective, welding activities that require long periods of standing and repetitive movements can cause muscle fatigue and long-term injuries. That's why using an ergonomic chair or support and rotating tasks can help.

Figure 5. Use of Welding Attributes



Source: <https://4emmesrl.it/en/processing/>

Other physical and environmental hazards include metal dust and welding fumes that build up due to inadequate ventilation, so installing proper ventilation systems and wearing standard respirators is really important to prevent breathing problems.

Figure 6. Use of Ventilation on a Welder



Source: <https://vattuuyvu.com/cac-loai-ong-hut-khoi-han.html>

Lastly, chemical hazards come from exposure to welding fumes containing toxic heavy metals, which can pose serious health risks if inhaled for a long time, so it's highly recommended to use a respirator mask and regularly monitor air quality.

Figure 7. Welder with Helmet Part



Source: <https://www.ishn.com/articles/>

By understanding and managing all potential hazards comprehensively, the safety and health of welding lab workers can be optimally maintained (Salvador, 2023).

Efforts to Control Health and Safety

Efforts to control occupational health and safety at SMK Negeri 10 Semarang are carried out through several important steps designed to minimize the risk of accidents and ensure worker safety, including: **First**, providing complete Personal Protective Equipment (PPE), including helmets, safety shoes, gloves, and protective glasses, is the top priority to protect workers from physical hazards and harmful substances. **Second**, systematically planning emergency evacuation routes ensures that everyone can move to a safe place quickly and orderly if an emergency happens. **Third**, arranging welding equipment and storing flammable materials carefully is done to reduce the risk of fires and welding-related accidents. And **fourth**, providing OHS training before practice, even though the duration is still limited, gives a basic idea about safety procedures, the use of PPE, and emergency actions, so workers have an initial understanding of the importance of workplace safety.

Implementing these steps reflects a proactive approach in creating a safe work environment and minimizing the risk of accidents and injuries (Benson dkk., 2024). To prevent workplace accidents (OSH) in the welding laboratory, SMK Negeri 10 Semarang enforces a number of strategic steps that are systematic and consistent, namely: **First**, create a written lab welding SOH SOP so that all safety procedures can be clearly followed and easily accessed by everyone in the lab. **Second**, strengthening supervision of the use of personal protective equipment (PPE) in every practice session, making sure every student and instructor wears welding helmets, gloves, safety glasses, and appropriate clothing. **Third**, installing local ventilation and welding fume extractors to reduce exposure to smoke and harmful gases that can affect long-term health. **Fourth**, adding hazard warning signs and safe work area markings, so that every lab user can easily recognize high-risk zones and follow safety protocols. And **finally**, hold regular health and safety training for new students every semester, so they get a good understanding of safe practices and risk management before starting lab activities. By consistently applying these steps, the risk of accidents and health impacts from welding can be significantly minimized, creating a safe and productive lab environment (Salvador, 2023).

DISCUSSION

The Importance of Knowledge Level in OHS Compliance

Based on the results presented above, the interpretation of the values shows that students have a fairly high understanding and awareness of occupational health and safety (OHS) in the laboratory, with the details as follows:

Risk Identification Aspect

The analysis results on the Risk Identification aspect show that the majority of students, around 83%, placed themselves in the Agree and Strongly Agree categories, indicating their ability to recognize potential hazards in the laboratory environment. This reflects a high level of awareness of safety risks, including familiarity with equipment that can cause injury, hazardous chemicals, and work procedures that could lead to accidents.

This ability is important for preventing laboratory incidents and enhancing learning effectiveness, as students not only follow procedures routinely but also actively anticipate and assess risky situations (Girmay dkk., 2024).

Possibility Analysis

Next, the analysis likely shows that 84% of students consider the risk of accidents to be quite high, reflecting a strong level of awareness of potential hazards in the work environment. This indicates that the importance of prevention is already ingrained in the students, so they tend to be more cautious and proactive in taking safety measures. With a solid understanding of risks, it is expected that students will not only recognize potential dangers but also actively take part in implementing preventive actions, such as using personal protective equipment, following safety procedures, and maintaining work discipline.

This situation shows that the workplace safety education program has successfully fostered a positive risk awareness culture among students, which is a key asset in creating a safe and productive work environment (Paweł Beś & Strzałkowski, 2024).

Impact Analysis

On the Impact Analysis side, the fact that 83% of respondents are aware that accidents can have serious consequences provides a clear picture of the high level of awareness regarding workplace safety risks. This awareness not only reflects individual understanding of potential physical and financial losses, but also emphasizes the urgency of consistently applying OHS standards across all operational levels. With a deep understanding of the impact of accidents, companies and related agencies are expected to take more effective preventive measures, including regular training, monitoring the implementation of OHS protocols, and providing adequate safety equipment.

Moreover, this level of awareness can serve as a positive indicator for developing a proactive safety culture, which will ultimately reduce the frequency of workplace accidents and improve overall worker productivity and well-being (Zwetsloot dkk., 2020).

Control Aspect

Meanwhile, in terms of Control, the majority of students, around 77%, feel that the K3 procedures have been properly implemented, which reflects that most people think the occupational health and safety system is effective and up to standard. However, 23% of students believe that the implementation of K3 procedures still needs improvement, indicating that there is room for better understanding, execution, and overall supervision.

This highlights the importance of regular evaluations, providing additional training, and raising collective awareness so that all students can experience the K3 implementation to the fullest, making the learning environment safer and more supportive of productivity (Tutunaru, 2023).

The interpretation of the data above shows that even though awareness and knowledge about K3 are already high, there is still room for improvement in implementing risk control so that the laboratory becomes a safer and more protected environment for all students.

The Impact of Work Experience

Workers with longer work experience have usually encountered various situations and risk scenarios in their operational scope, so they can recognize potential hazards more quickly and take appropriate preventive measures (Priolo dkk., 2025). A deep understanding of safety procedures, work culture, as well as the characteristics of equipment and production processes allows them to assess risks more accurately compared to newly joined workers (Amirah dkk., 2024). Therefore, experienced workers tend to have lower risk scores, reflecting their ability to manage and mitigate risks effectively, while also contributing positively to overall safety and smooth operations. This phenomenon aligns with the learning curve principle, which shows that as experience increases, competence and accuracy in decision-making improve, and the potential for operational errors decreases (Horowitz & Kahn, 2024).

Longer experience can also strengthen the safety culture in the industry, because experienced workers are more aware of safety practices, can recognize potential hazards more quickly, and actively promote safe behavior among their peers (Amirah dkk., 2024). The integration of individual experience with organizational learning systems creates a continuous improvement cycle, where better risk awareness supports safer decision-making, boosts operational efficiency, and reduces workplace incident rates. Therefore, investing in skill development through practical experience and structured learning is very important in building a safer and more productive work environment.

The Role of the Work Environment

Work environments that involve sharp tools, moving machinery, or exposure to chemicals can increase the risk of accidents and health issues for workers (belkher & Masood, 2023). Quantitative risk analysis shows that these hazards don't just threaten physical safety, but can also affect productivity and work quality. That's why a combined approach is needed, which includes ergonomic principles to match equipment and the work environment to workers' physical abilities, as well as safety engineering measures to minimize mechanical, chemical, and physical risks (Hasanain, 2024).

Concrete steps, like designing ergonomic and standard-compliant personal protective equipment, arranging workflow systematically to minimize accident risks, implementing automated machine monitoring to detect potential hazards in real-time, as well as intensive employee training and layered risk mitigation procedures, are essential components of a comprehensive safety strategy (Mubasher dkk., 2026). By integrating all these elements, organizations not only ensure compliance with existing safety regulations, but also foster a proactive health and safety work culture, boost productivity by reducing workplace incidents, and build a socially, economically, and environmentally sustainable work environment (Bernal dkk., 2024). This approach promotes the creation of a resilient organization, capable of handling operational risks, and empowers each individual to contribute to creating a safe and optimal work environment.

Practical Implications

The implications of research related to Occupational Health and Safety (OHS) show that companies have significant opportunities to reduce OHS risks through a series of strategic actions, including:

First, Ongoing training programs for all employees play a key role in creating a safe and productive work environment. By regularly providing material on risk identification, safety procedures, and emergency handling simulations, employees not only raise their awareness of potential hazards but also sharpen practical skills to deal with them effectively. In addition, continuous training helps build a safety culture at work, encourages open communication about potential risks, and strengthens team coordination skills during critical situations (Zulkarnain & Lestari, 2025).

Second, Increasing supervision in high-risk areas not only allows for early identification of behaviors or conditions that could lead to accidents, but also strengthens the overall safety management system. With more intensive monitoring, any deviations or warning signs can be spotted quickly, so corrective or preventive actions can be implemented promptly and effectively. Additionally, consistent supervision helps build a safety culture among workers, boosts compliance with safety procedures, and reduces the chances of more serious incidents. The integration of technologies like automatic sensors, CCTV, and real-time reporting systems can also help improve monitoring, so interventions can happen before risks turn into actual accidents, providing more proactive protection for people's safety and company assets (Kheder & Mohammed, 2024).

Third, Reorganizing the work floor, vehicle routes, and systematically installing safety indicators is an important step in creating an organized and safe work environment. By implementing a structured layout plan, each area has a clear function, and the movement paths for vehicles and pedestrians are limited to designated routes, reducing the risk of collisions and potential injuries. In addition, installing visual indicators, like direction signs, boundary lines, and safety warnings, makes it easier for workers to recognize potential hazards and guide them to stay on safe paths.

This combination of physical setup and visual communication not only boosts safety but also operational efficiency, because a clearer workflow allows for better coordination between units, reduces waiting times, and minimizes mistakes due to wrong navigation (Ruddro & Mohna, 2023). With this systematic approach, organizations can create a proactive safety culture, where everyone actively participates in keeping themselves and their coworkers safe, while also building a more productive and harmonious work environment. By applying these three steps together, the company can not only reduce occupational health and safety risks but also build a sustainable and integrated safety culture throughout the organization.

CONCLUSION

The results of a questionnaire given to 30 10th-grade Welding Engineering students at SMK Negeri 10 Semarang showed that the implementation of occupational safety and health (OSH) in the welding lab is fairly good. The risk identification aspect scored 83%, the likelihood analysis 84%, and the impact analysis 83%, indicating that students are highly aware of potential hazards and accident consequences. However, the existing controls aspect only reached 77%, meaning that 23% of students think that safety control measures are not yet fully effective. This condition reflects that

even though awareness of risks and impacts is high, the implementation of technical and procedural controls still needs to be strengthened to make the learning environment safer and more consistent.

The Pearson correlation test showed that all aspects of K3 (Occupational Health and Safety) have a positive and significant correlation with student learning outcomes. The Probability/Likelihood aspect had the strongest correlation ($r = 0.614$, $p = 0.000$), followed by Risk Identification ($r = 0.582$, $p = 0.001$) and Consequence/Severity ($r = 0.553$, $p = 0.002$). Meanwhile, Existing Controls showed a weaker correlation ($r = 0.471$, $p = 0.012$), though it was still significant. These findings confirm that the higher the students' awareness of risks and the likelihood of accidents, the better their practical scores. On the other hand, weak safety controls can hinder consistent performance. Thus, the safety ecosystem in the welding lab at SMK Negeri 10 Semarang clearly plays a direct role in boosting students' vocational skills, while also highlighting the need to strengthen control measures for more stable and optimal competency achievement.

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