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Strategy for Improving SMAW Welding Practice Learning: Case Study at Vocational High School

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ABSTRACT

Welding is one of the most essential competencies in the metal fabrication industry. Therefore, effective SMAW (Shielded Metal Arc Welding) practice learning strategies are critical to ensuring quality learning outcomes. In vocational high schools (VHS), however, challenges persist, such as low student performance, joint defects, and a lack of industry-relevant learning models. These issues underscore the need for a more in-depth examination of practical learning strategies and efforts to enhance student competencies, an area that remains underexplored. This study aims to explore strategies for improving SMAW practice learning through a single-case study conducted in a vocational high school (VHS). Data were collected via in-depth interviews with six welding teachers and four certified student welders, supported by document analysis. The findings indicate that three main strategies are essential: (1) understanding and application of welding parameters by students, (2) intensive mentoring from teachers, and (3) independent evaluation by students. These strategies have the potential to enhance both understanding and performance in SMAW practical learning in vocational settings.

Introduction

The Indonesian education system is currently undergoing significant transformation in response to the challenges posed by the Industrial Revolution 4.0 and the rapid pace of globalization. These forces have accelerated technological advancements and intensified labor mobility and competition at the regional level, particularly within the ASEAN Economic Community (Fajar & Hartanto, 2019;

Ministry of Education and Culture, 2016). In this context, vocational education plays a critical role in preparing a skilled workforce that can meet the demands of modern industry.

Vocational High Schools (VHS) represent a key component of secondary vocational education in Indonesia, typically delivered over a three- or four-year period. Their primary objective is to prepare students for immediate entry into the workforce or to become entrepreneurs (Ministry of Education and Culture, 2016). By focusing on training for specific occupations, vocational education aims to improve youth productivity and foster independence (Bunawar, 2022; Fuller, 2015). As Indonesia anticipates a demographic bonus by 2045—when an estimated 70% of its population will be of productive age—strengthening vocational education has become increasingly urgent to ensure national competitiveness.

Despite these goals, the effectiveness of VHS programs continues to be questioned. Graduate employment remains one of the main indicators of vocational education success (Belaya, 2018; Kurniawan et al., 2021). However, recent data from the Central Bureau of Statistics indicate that the unemployment rate among VHS graduates remains relatively high, at 11.45% in 2021, 10.38% in 2022, and 9.6% in 2023 (Central Bureau of Statistics, 2023). Although the trend is decreasing, these figures indicate a mismatch between the supply of vocational graduates and the labor market's demands. Industries may still prefer candidates from other educational levels, including higher or even lower than VHS.

To address this gap, VHS graduates must possess not only academic competence but also strong technical and employability skills (Bennett, 2006; Fajaryati et al., 2020). National education standards guide these competencies and serve as benchmarks for vocational graduate readiness. One of the specialized programs within VHS is welding engineering, where graduates are expected to master practical skills aligned with industrial requirements (Ministry of Manpower, 2016). To enhance their employability, students are encouraged to earn competency certifications in line with labor market standards (Daryono et al., 2020; Rahmah & Muslim, 2019).

Among the various welding techniques taught in VHS, Shielded Metal Arc Welding (SMAW) is one of the most widely used. SMAW is entirely manual, and the quality of the weld depends significantly on the welder's skill. SMAW practice learning focuses on the ability to make weld joints in various positions using carbon steel. Key performance parameters in SMAW include electrode diameter, welding current, polarity, and welding speed (Haider et al., 2019; Qazi et al., 2020). The expected learning outcomes include identifying machine specifications, preparing equipment and materials, selecting appropriate electrodes, performing welds, and conducting visual inspections

following national test standards (Decision of the Head of the Educational Standards, Curriculum and Assessment Agency, 2022).

Learning strategies play a central role in the success of vocational education. These are the methods or techniques used by teachers to facilitate student learning (Bunawar, 2022; Shi, 2017). The effectiveness of a strategy depends on contextual factors such as teacher competence, student characteristics, available media, and facility support (Safriwardy et al., 2022). In the context of SMAW practice, effective strategies often involve project-based learning that simulates real industrial tasks. However, several problems persist in SMAW teaching, including low student competency certification rates (Hargiyarto et al., 2020; Munadi et al., 2020), insufficient hands-on training (Ardin & Mujiono, 2016), limited practice time, lack of equipment, and minimal access to consumable materials (Bahora & Mujiyono, 2019).

Previous research has examined various aspects of welding instruction, such as the stages of job-sheet-based learning and the use of evaluation frameworks (Bahora & Mujiyono, 2019). Nonetheless, studies have consistently reported issues such as joint defects in student welds, indicating limited practical competence (Ardian et al., 2023). The results of other studies on the indicator of welding processes in teaching and learning practices include practical learning strategies, recommending a deeper examination of welding practice learning (Ariyanto et al., 2022). Furthermore, VHS education requires a unique approach to learning, as per the industry's criteria (Ahmad & Rofiq, 2020; Sukardi et al., 2020; Syauqi et al., 2022). Based on researchers' knowledge and previous studies, there is still limited information available about how students can conduct welding effectively and the strategies teachers use to train students in SMAW welding.

Despite these findings, little research has explored how teachers train students to perform effective SMAW welding or how students experience the learning process. Therefore, this study is urgently needed to (1) identify instructional strategies that develop student competence, (2) improve the effectiveness of SMAW welding instruction, and (3) align learning approaches with the needs and characteristics of vocational students in the welding program.

Method

Research Design

This study employs a qualitative, single-case approach to explore the case under examination. The selection of a single-case study aims to explore and examine a complex phenomenon, thereby increasing understanding and explaining it (Creswell & Creswell, 2018; Vredenburgh & Vanderpol,

2014). This type of case study is designed to understand the phenomenon within the organization and gather more detailed and focused data, allowing the study results to be described with greater explicitness and detail (Lavarda & Bellucci, 2022; Yin, 2009). The researcher selects a striking and representative case of a specific phenomenon, then thoroughly examines the case and provides a detailed description to illustrate the phenomenon (Lune & Berg, 2017; Yin, 2018). Researchers focus on cases in one vocational school with unique characteristics as an analysis unit and then conclude the cases to illustrate the problem. Furthermore, case studies are used to answer how and why, as well as to identify practical methods to improve learning (Ganie et al., 2022; Yazan & De Vasconcelos, 2016; Yin, 2009), thereby enabling the researcher to gain an understanding of the characteristics and theory behind the implementation of strategic learning in SMAW welding at VHS.

The research is based on the phenomena in the VHS Welding Technical Expertise Program, which implements strategies to improve effective and efficient Practice Learning. This study illustrates how case studies can increase understanding of individual phenomena, organizations, or specific units in a unique way (Creswell & Creswell, 2018; Glette & Wiig, 2022; Yin, 2009). In this context, the case identification process in the study was conducted through a preliminary study tailored to the purpose and research needs. The first step in the preliminary study is to find objects and subjects relevant to the topic of the SMAW practice learning strategy at VHS. The selection of VHS, which will serve as the research location, is based on its characteristics, track record, experiences, and contributions to welding education.

Indicators used by researchers in determining VHS are based on (1) Having national and international achievements; (2) Having the highest number of teachers in internships, training, and competency certification in the field of welding; (3) Having the highest number of students in competency certification in the welding field; (4) teachers and students often win competitions in the field of welding; (5) the most graduates are absorbed in the industry; (6) able to produce skills that are following industrial needs; and (7) the quality of graduates with high levels of work. The seven indicators are a unique feature or indicator of VHS's ability to carry out effective and efficient SMAW practices, which will impact competency certification, the quality of graduates, and the integration of students into the workforce.

Participants

Data source collection techniques are selected by purposive sampling. The informant selection process is based on identifying involvement, experience, and reputation in learning the practice of SMAW welding. The selection of informants must be based on experience relevant to the data source

to be collected (Pacho, 2015; Yin, 2009). Participants are chosen based on the suitability of cases that allow it to enrich data, expand the relationships and logic of the selected case, and uncover various realities (Eisenhardt & Graebner, 2007; Tsang et al., 2019). Researchers aim to understand participants' experiences in the teaching and learning process within the learning practices of SMAW welding so that the chosen participants can provide a comprehensive understanding of the implementation of SMAW practical learning at VHS. The number of informants selected, up to ten people from VHS, along with the corresponding information, is presented in the following table.

Table 1. Selected informant data

No.	*Name (anonymous)*	*Position classification*	*Gender*	*Certificate Holder in welding*
1.	Yanto	Deputy Head of Curriculum	Male	-
2.	Siswo	Deputy Head of Infrastructure	Male	Welder 6G
3.	Supri	Head of Skills Program	Male	Welder 6G
4.	Samir	Welding teacher	Male	Welder 6G
5.	Radi	Welding teacher	Male	Welder 6G
6.	Habib	Welding teacher	Male	Welder 6G
7.	Riko	Certified students	Male	Welder 6G
8.	Hari	Certified students	Male	Welder 3G
9.	Bagus	Certified students	Male	Welder 3G
10.	Adi	Certified students	Male	Welder 3G

Data Collection

We began to collect research data from June to December 2024. We use only two sources of evidence from the research data: the transcribed interview results and the document study findings. Determination of data sources is based on the relationship between the questions asked, the data that was successfully collected, and the conclusions drawn.

First, data collection begins by compiling questions for the interview protocol and creating a list of necessary documents. Documents play a crucial role in verifying, refining, and synthesizing information from the interview process and other sources of evidence (Yin, 2018). The Use of protocols aims to increase the accuracy of research and guide researchers in collecting data (Yin, 2009). After compiling the interview protocol, we validated it by asking the interview questions to two experts: one with expertise in practical learning strategies and another in welding techniques. After going through the validation process, we made revisions based on the input and suggestions provided by the experts.

Second, we conducted pilot studies that helped researchers to test and perfect data collection sources. Pilot studies can improve research quality by anticipating challenges in the field (Malmqvist

et al., 2019; Yin, 2009). We provide information about the pilot study conducted and provide feedback related to the interview protocol. The selected participants were representative VHS with the case raised.

Third, we initiated data collection by conducting in-depth interviews with ten participants from VHS, comprising both teachers and students. Before the interview process begins, we provide all relevant information to participants regarding the objectives and procedures that will be followed during the interview. Participants could refuse or withdraw from the study by signing a consent document. We guarantee that participation in this research is entirely voluntary. Participants can withdraw at any time and refuse to answer questions during the interview or data collection process. It is also guaranteed that all identities, including names, places, and locations, will be kept confidential in accordance with applicable research ethical standards. Fortunately, all ten participants voluntarily and openly agreed to be interviewed and permitted the recording of their conversations. The interview questions asked of participants were based on their perspectives regarding SMAW welding practical learning strategies, including preliminary learning activities, practical learning processes, student participation, tests and evaluations, and follow-up activities.

We used Indonesian during the data collection process. Each participant underwent an interview with an average duration of approximately 60-90 minutes, and the interview was recorded using a smartphone device. During the interview process, we also collect relevant documents. We request permission to obtain duplicate documents if possible. The documents we receive as supporting data include curriculum, graduate profiles, job sheets and teaching materials, syllabi, learning plans, and student evaluation results.

Data Analysis

Data collected from the field was carefully translated verbatim into text form and entered into the ATLAS.ti 9.0 software to assist the data analysis process. The data analysis method used is pattern matching. The pattern matching process goes through five steps, namely: (1) Data selection, by selecting several quotes from each data that is considered significant or exciting; (2) Giving coding, by making labels in the form of words or sentences given to the quotations; (3) Data grouping, including relationship analysis, classification and data discovery based on previously created codes; (4) Data code categorization, organizing to make it easier to find information and easier to understand; (5) Creating a concept map, which involves exploring the relationship between findings based on categories, quotations, and coding.

Trustworthiness

Data trustworthiness in this research was carried out to confirm the validity of the data, as well as the interpretation and findings obtained. We returned interview transcripts to participants as a member-checking step to verify and validate the conformity between our transcripts and the information they had submitted (Birt et al., 2016; Santos et al., 2017). By involving participants in this process, we can reduce potential researcher bias and ensure the reliability of the findings (Doyle, 2007). Additionally, we maintained ongoing communication, established close relationships with participants throughout the data collection process, and conducted repeat interviews to gain a deeper understanding. We also conduct the dependability process by conducting a comprehensive review and audit of all research stages in collaboration with the research team.

Result and Discussion

SMAW welding is a manual welding technique that largely depends on the welder's skills in executing the welding process. The findings are presented in response to the main research question: "What is the strategy to improve learning of SMAW welding practices at VHS?" Based on the results of data analysis, it was found that there were three critical aspects in the strategy to improve practical learning of SMAW welding at VHS, namely: (1) understanding and application of welding parameters by students, (2) intensive mentoring from teachers, and (3) independent evaluation by students. The identified vital components can be further explained as follows.

Understanding And Application of Welding Parameters by Students

A significant factor influencing welding quality is the student's ability to understand and apply key welding parameters, such as electrode type, current and voltage settings, arc length, travel speed, welding position, and defect control. Interviews revealed a shared perception among teachers that mastering these parameters is essential to producing welds that meet industrial standards. One teacher (P6) stated, "We integrate welding parameters in all practice sessions, and students must consistently apply them in every project." Another added, "Students should understand and apply settings like current, electrode control, and welding position accurately" (P2).

Students confirmed the importance of technical control, as expressed by a certified participant: "The most crucial basic skill is adjusting current and voltage correctly. If they're off, the weld won't meet standards" (P8). This indicates that effective SMAW learning begins with theoretical clarity, followed by applied understanding during practice.

The literature supports this emphasis on parameter mastery as a foundation for successful

welding practice (Setiawan et al., 2023; Srinatriyo et al., 2023). The direct application of theory through hands-on experimentation enhances student competence, enabling them to recognize the relationship between parameter settings and weld quality (Ramreddy et al., 2014). Furthermore, this process cultivates analytical and critical thinking as students evaluate their outcomes. Accurate parameter control not only reduces defects but also builds students' readiness to work in industrial contexts with high-quality expectations.

Intensive assistance from teachers

Teacher support during welding practice proved to be a vital strategy for enhancing student competence and confidence. Teachers emphasized the importance of close guidance in maintaining safety and improving technique. One teacher remarked, "We assist students to ensure proper technique, correct errors, and uphold safety standards" (P2). Another highlighted the developmental aspect, stating, "Teacher assistance builds student confidence and professional readiness" (P1).

Students echoed this sentiment, noting that teacher involvement significantly enhanced their learning. One student shared, "My mistakes were corrected immediately thanks to my teacher's feedback, which helped me improve quickly" (P7).

The importance of mentoring is consistent with previous research that underscores the role of instructors in facilitating skill development, managing individual learning paces, and modeling proper procedures (Ryökkynen et al., 2020; Shao, 2022). Teachers serve as mentors, supervisors, and evaluators, organizing and managing the practice environment to ensure quality and shape students' technical and cognitive abilities (Kilbrink & Asplund, 2020; Peng et al., 2022). Regular teacher-student interaction fosters a learning environment where students feel supported, engaged, and motivated to overcome learning difficulties.

Moreover, mentoring enhances problem-solving, communication, and critical thinking—core competencies expected of vocational graduates in the 21st century (Mariah & Sari, 2019; Sun et al., 2008). Therefore, a structured mentoring approach involving demonstration, feedback, and adaptive instruction is indispensable in effective SMAW learning.

Independent evaluation by students

The third key strategy involves encouraging students to independently evaluate their welding outcomes. This practice develops metacognitive skills by prompting students to assess their progress and identify areas for improvement. Evaluation techniques, such as visual inspection and destructive or non-destructive testing (based on AWS or ASME standards), allow students to

compare results against objective criteria.

Teachers highlighted the value of involving students in self-assessment. One explained, "Self-evaluation is more effective when students set their assessment criteria. It enhances awareness of welding quality" (P6).

Students also recognized the benefits of reflective evaluation. One participant noted, "Self-evaluation helped me understand how welding parameters impact results" (P10), while another added, "It gave me clarity on what needed improvement to meet standards" (P9).

Research confirms that self-evaluation supports the development of autonomy, accountability, and diagnostic thinking (Chan & Leijten, 2012; Huang et al., 2020). When students regularly assess their performance, they are more likely to internalize learning objectives, detect errors early, and adjust their practices accordingly (Seitova et al., 2022). These habits are essential for preparing students to operate independently in industry settings, where quality control and precision are paramount.

Synthesis and Model of SMAW Practice Learning Strategy

The findings suggest that SMAW welding practice should employ a holistic learning strategy that integrates (1) understanding and application of welding parameters by students, (2) intensive mentoring from teachers, and (3) independent evaluation by students. Together, these strategies foster a learning environment that supports skill acquisition, critical reflection, and personal responsibility. Based on the research results, a learning strategy model for SMAW welding practice can be formulated, as shown in the following figure.

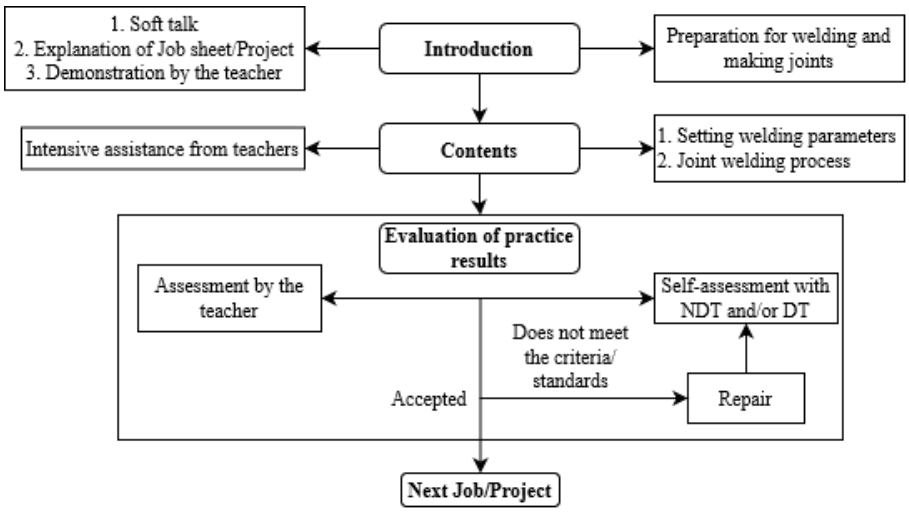

Fig 1: Formulation of a learning strategy model for SMAW welding practice

This case study focused on a single vocational high school recognized for its effective implementation of SMAW practices. As such, the findings may not fully represent all VHS contexts. Nonetheless, the results provide valuable insight into effective instructional strategies for welding practice. For future research, it is recommended that more vocational schools be involved as research locations and that mixed qualitative and quantitative research methods be considered. In addition, this research can consider various aspects, including the development of effective practical learning methods to improve vocational school students' competency in welding.

Conclusion

This study concludes that effective learning strategies for SMAW welding practice in Vocational High Schools (VHS) consist of three interrelated components: understanding and application of welding parameters by students, intensive assistance from teachers, and independent evaluation by students. Understanding welding parameters forms the technical foundation necessary for producing quality welds, while teacher mentoring supports the development of skills, confidence, and safety awareness during practice. Furthermore, independent evaluation fosters student autonomy and critical thinking in assessing and improving welding outcomes. These three strategies, when implemented cohesively, contribute to improving the quality and effectiveness of SMAW learning and can serve as a practical model to prepare vocational students for industrial demands.

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