Effectiveness of using video tutorial-based learning media in the SMAW welding techniques course

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Abstract: This study examined the effectiveness of video tutorial–based learning media in improving students' mastery of horizontal-position Shielded Metal Arc Welding (SMAW) in a technical and vocational education and training (TVET) context. The study responded to the limited evidence on position-specific digital instructional media in welding education, particularly for horizontal-position SMAW practice, which requires precise control of movement, angle, and bead formation. A pre-experimental one-group pretest-posttest design was employed involving 30 Grade XI students in the Mechanical Engineering program at SMKN 1 Sumatera Barat. Data were collected using a validated 30-item performance assessment covering preparation, process, and final weld quality, and were analyzed using descriptive statistics and a paired-samples t-test in IBM SPSS Statistics. The results showed a substantial improvement in students' performance after the intervention. The mean score increased from 47.57 in the pre-test to 81.70 in the post-test, with a mean gain of 34.13 points. The paired-samples t-test revealed a statistically significant difference, $t(29) = 15.25$, $p < 0.001$, and the effect size was very large ($d = 2.78$). These findings indicate that video tutorial–based media can serve as an effective, low-cost, and scalable instructional tool for procedural welding skills. The study contributes to digital pedagogy in TVET by highlighting the importance of pedagogical fit in technology-supported practical instruction.

Keywords: TVET; video tutorial–based learning; SMAW welding; horizontal-position welding; procedural skill learning; vocational education

1. Introduction

Technical and vocational education and training (TVET) is undergoing rapid digital transformation as institutions are pressed to align teaching practices with Industry 4.0, evolving workplace demands, and student-centered learning models (Huda et al., 2023; Leong, 2025; Rajamanickam et al., 2024). In this context, classroom instruction can no longer rely mainly on one-way explanation, especially in skills-based courses that require repeated observation, guided practice, and procedural accuracy. Research on active learning has consistently shown that student engagement improves learning outcomes compared with traditional lecture-dominant instruction, while recent TVET scholarship emphasizes that digital transformation should not only digitize content but also improve the effectiveness, accessibility, and relevance of practical training (Aldhafeeri & Alotaibi, 2022; Nyongesa & Westhuizen, 2025; Rossi et al., 2021; Zou et al., 2025). These developments make instructional media a central issue in vocational education, particularly in courses where students must master visible, sequential, and safety-sensitive procedures (Freeman et al., 2014; Parua & Yang, 2024).

Among digital media, video tutorials are especially relevant for procedural and practice-oriented instruction because they can present action sequences through synchronized visual and verbal explanation, reduce unnecessary cognitive load when well designed, and allow students to review critical steps repeatedly at their own pace (Sha & Chiu, 2025; Staneviciene & Žekiene, 2025; Yueh et al., 2025). Recent evidence from procedural-skills education also suggests that structured and segmented video demonstrations can improve student performance more effectively than non-interactive video exposure alone (Hamzah et al., 2025; Monib et al., 2025; Qi et al., 2026). For vocational learners, these features are particularly valuable because procedural competence is often built through repeated viewing, imitation, correction, and practice readiness rather than through verbal explanation alone. In other words, video tutorials are not merely supplementary media; they can function as instructional scaffolds for psychomotor and procedural learning (Brame, 2016; Hamzah et al., 2025).

This issue is highly relevant in welding education. Recent studies show growing interest in digital media for welding and vocational training, including immersive VR environments, augmented reality–integrated teaching modules, and YouTube-based SMAW learning channels (Alfaro-Viquez et al., 2025; Chan et al., 2022; Prasetya, Fajri, et al., 2023; Yunus et al., 2025). These studies indicate that digital delivery is increasingly seen as necessary to improve student engagement, conceptual understanding, and access to practical demonstrations. However, the current direction of innovation is dominated by immersive or platform-based approaches that may demand additional infrastructure, technical support, or broader curricular redesign (Pasi & Dhamak, 2025; Tang et al., 2025). At the same time, vocational institutions still need instructional media that are pedagogically strong, technically specific, and feasible to implement in routine classroom and workshop settings (Ismail et al., 2025; Thomann et al., 2024).

Despite this progress, an important gap remains. Existing studies in welding education have tended to address general SMAW topics, broad digital platforms, or technology-enhanced modules, while evidence on position-specific video tutorial media remains limited (A. R. Ahmad et al., 2024; Papakostas et al., 2022; Syauqi et al., 2025). This gap matters because welding positions differ in technical demands, depending on workpiece orientation and operational accessibility, so learners often require more precise visual guidance for specific positions than for general welding introduction (Costanza et al., 2025; Koçak et al., 2025; Morais Júnior et al., 2020). The horizontal position, in particular, is not simply another topic within SMAW instruction; it demands accurate control of movement, angle, and bead execution that may be difficult for novice learners to understand from a static explanation or brief teacher demonstration alone. Thus, while recent studies support digital innovation in welding education, the effectiveness of video tutorial–based learning media specifically designed for horizontal-position SMAW practice remains underexplored (Ismail et al., 2025; Yunus et al., 2025).

This study addresses that gap by examining the effectiveness of video tutorial–based learning media in the SMAW welding techniques course, with a specific focus on the horizontal position. The study offers three main contributions. First, it shifts attention from broad or platform-level digital innovation to a position-specific instructional medium for a technically demanding SMAW task. Second, it highlights a low-cost, scalable alternative to infrastructure-intensive technologies such as virtual and augmented reality, making the intervention more feasible for routine vocational teaching practice. Third, it examines not only the presence of digital media in welding instruction but also its pedagogical value in supporting student-centered learning and procedural skill acquisition. Accordingly, this study is guided by the following research question: Does video tutorial–based learning media significantly improve students' mastery of horizontal-position SMAW welding?

This study contributes to the emerging literature on digital pedagogy in TVET by demonstrating that the value of instructional technology lies not only in technological sophistication, but also in pedagogical fit with the procedural demands of vocational tasks. Specifically, it extends welding education research by testing a position-specific video tutorial intervention for horizontal-position SMAW practice, an area that has received far less attention than general SMAW instruction or immersive technology-based innovation. The study also offers practical relevance by proposing an instructional medium that is comparatively low-cost, scalable, and feasible for routine classroom and workshop implementation. Taken together, these contributions position the study at the intersection of digital transformation, procedural skill learning, and accessible pedagogical innovation in vocational education.

2. Methods

2.1 Research Design

This study employed a pre-experimental design with a one-group pretest-posttest structure to examine the effectiveness of video tutorial–based learning media in the SMAW welding techniques course, particularly for horizontal-position welding. This design was selected because the study was conducted in an authentic school setting, where the researcher had access to only one intact class and no comparable control group. In educational research, a one-group pretest-posttest design is commonly used to evaluate whether measurable changes occur after an intervention when random assignment and comparison-group arrangements are not feasible (Creswell, 2009; Knapp, 2016).

The design allowed the study to compare students' performance before and after the intervention within the same group. In this way, the study focused on whether the implementation of video tutorial–based learning media was followed by improvement in students' mastery of horizontal-position SMAW welding. Although this design does not permit strong causal comparison with conventional instruction, it is appropriate for obtaining initial evidence of instructional effectiveness in a real vocational classroom context (Cook et al., 2013; Wittwer & Renkl, 2008). The overall structure of the research design is illustrated in Figure 1.

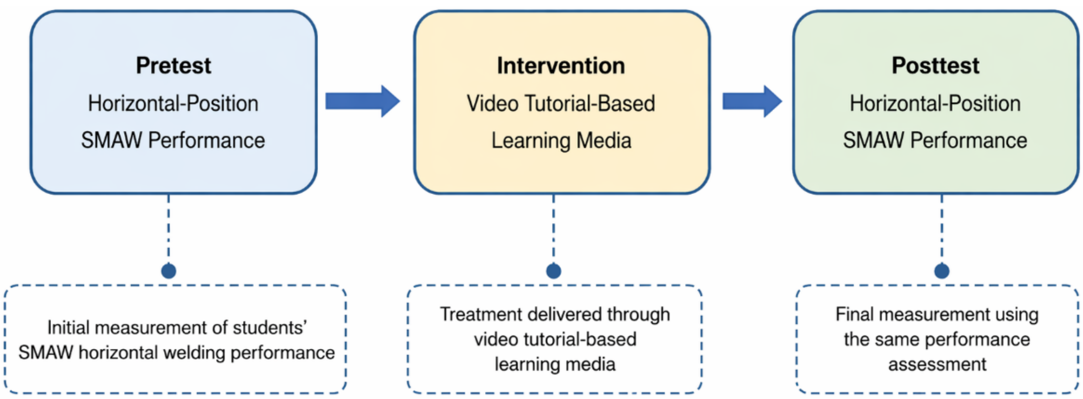

Figure 1. One-group pretest-posttest research design

2.2 Research setting and participants

The study was conducted at SMKN 1 Sumatera Barat in the SMAW welding techniques course. The participants were 30 Grade XI students enrolled in the Mechanical Engineering program. The participants were selected through convenience sampling, based on classroom accessibility, the school timetable, and institutional permission to conduct the intervention. Convenience sampling is frequently used in school-based research when access to participants depends on administrative and scheduling constraints (Cook et al., 2013; Wittwer & Renkl, 2008).

The participants represented one intact class that was already taking welding practice as part of its regular vocational instruction. Because all students belonged to the same class, the study did not divide them into experimental and control groups. Instead, the same participants completed both the pre-test and the post-test, allowing changes in performance to be examined over time within the same cohort. A summary of the research setting and participant characteristics is presented in Table 1.

Table 1. Research setting and participant profile

Aspect	Description
Research site	SMKN 1 Sumatera Barat
Educational level	Grade XI vocational students
Program	Mechanical Engineering
Course	SMAW Welding Techniques
Sampling technique	Convenience sampling
Number of participants	30 students
Participant type	One intact class
Research design	Pre-experimental, one-group pretest-posttest

2.3 Intervention

The intervention consisted of video tutorial–based learning media designed for horizontal-position SMAW welding. The instructional content covered two main topics: occupational safety and health (OSH) in welding practice and the technical procedures of horizontal-position welding, including preparation, electrode handling, welding angle, welding speed, and final weld quality. Video tutorials are particularly suitable for procedural and psychomotor learning because they combine visual demonstration and verbal explanation, allow repeated viewing, and help students observe movement sequences more clearly than oral explanation alone (Alkahtani et al., 2025; Botelho et al., 2018; Cooper & Higgins, 2015).

The instructional session was held during one scheduled week of the SMAW course, in accordance with the school's timetable. The learning process was facilitated by a welding teacher at SMKN 1 Sumatera Barat with more than 5 years of teaching experience. During the intervention, students first received a brief teacher introduction to the lesson objectives, then watched the video tutorial, followed by guided explanation and practical welding activities. The teacher also provided clarification and live reinforcement during the practice phase to ensure that students could connect the content shown in the video with actual workshop procedures. This intervention format was chosen because vocational instruction often requires students to observe, imitate, and repeat technical procedures before performing them independently. In such contexts, video tutorial media can function as an instructional scaffold that supports both procedural understanding and practice readiness (Nooijen et al., 2024).

2.4 Instrument and data collection

Data were collected using a performance assessment sheet for horizontal-position SMAW welding. A performance-based instrument was considered more appropriate than a written test because the outcome of interest was students' practical mastery of welding procedures and weld quality. Performance assessment is widely recommended in vocational and technical education when the target learning outcomes involve procedural execution, tool use, safety compliance, and product quality (A. Syahid Robbani, 2021; Yusop et al., 2022).

The instrument consisted of 30 items that had previously undergone validation and reliability testing. The items were grouped into three domains: preparation, process, and final result. The preparation domain covered the completeness of personal protective equipment, tool readiness, and the appropriateness of welding current settings. The process domain assessed electrode angle, movement control, and welding speed. The final-result domain focused on visual evaluation of the weld, including surface appearance, weld defects, and slag removal. The same instrument was used in both the pre-test and post-test to maintain consistency across the two measurement points. The instrument's structure is summarized in Table 2.

Table 2. Structure of the performance assessment instrument

Domain	Focus of assessment	Indicators	Number of items
Preparation	Readiness before welding	PPE completeness, tool readiness, and current appropriateness	10
Process	Welding execution	Electrode angle, movement control, and welding speed	10
Final result	Weld quality	Surface appearance, weld defects, slag removal	10
		Total	**30**

2.5 Research procedure

The study was conducted in three main stages: pre-test, intervention, and post-test. In the first stage, all students performed horizontal-position SMAW welding under the same workshop conditions. Their performance was assessed using the welding performance sheet to establish baseline data before the intervention. In the second stage, students participated in a learning session that incorporated video tutorial–based learning media. During this session, the teacher introduced the learning objectives, presented the video tutorial, explained the key technical points, and guided students through the practical stages of horizontal-position SMAW welding. The lesson emphasized both procedural understanding and readiness for practice. In the third stage, students were asked to perform horizontal-position SMAW welding again. Their post-intervention performance was assessed using the same instrument and criteria applied during the pre-test. Using the same participants, the same skill task, and the same assessment criteria at both stages was important to ensure that score differences reflected changes in student performance rather than variations in testing conditions (Creswell, 2009). The overall sequence of the research procedure is shown in Figure 2.

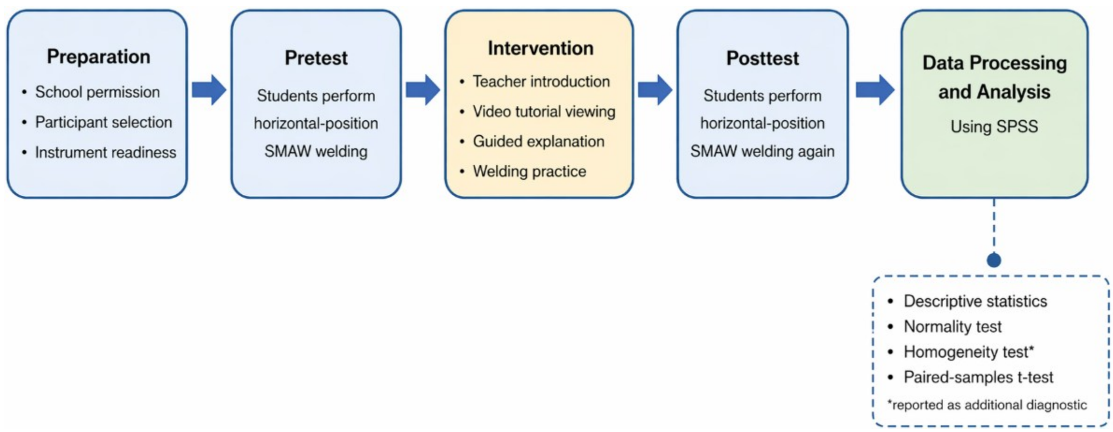

Figure 2. Research Procedure

2.6 Data analysis

The data were analyzed using IBM SPSS Statistics. The analysis began with descriptive statistics to summarize students' pre-test and post-test scores, including the mean, standard deviation, minimum, and maximum scores. These descriptive results were used to provide an overall picture of student performance before and after the intervention. Furthermore, the normality assumption was examined using the Kolmogorov–Smirnov test. A significance value greater than 0.05 indicated that the data met the normality assumption required for parametric analysis. As an additional diagnostic, Levene's test was also reported to describe variance similarity, although homogeneity of variance is not the principal assumption for a paired-samples t-test. Finally, the main hypothesis was tested using a paired-samples t-test to determine whether there was a statistically significant difference between pre-test and post-test scores after the implementation of the video tutorial–based learning media. The level of significance was set at 0.05. A p-value below 0.05 indicated that the intervention was associated with a significant improvement in students' horizontal-position SMAW welding performance. For clarity, the sequence of analytical procedures used in this study is summarized in Table 3.

Table 3. Data analysis procedures

Stage	Analysis	Purpose	Software
1	Descriptive statistics	Summarize pre-test and post-test performance	SPSS
2	Kolmogorov–Smirnov test	Examine normality of difference scores	SPSS
3	Levene's test	Provide additional diagnostic information on score dispersion	SPSS
4	Paired-samples t-test	Test whether post-test scores differ significantly from pre-test scores	SPSS

3. Results

3.1 Descriptive statistics

The descriptive analysis shows a clear improvement in students' horizontal-position SMAW welding performance following the implementation of the video tutorial–based learning media. Overall, post-test performance was substantially higher than pre-test performance. Students achieved a mean score of 81.70 (SD = 9.03) on the post-test, compared with 47.57 (SD = 15.57) on the pre-test, indicating an average gain of 34.13 points. The post-test also produced a higher median and a narrower score distribution, suggesting that the intervention was associated not only with improved average performance but also with greater consistency across students. A more detailed summary of the descriptive results is provided in Table 4. As shown, the minimum score increased from 20 in the pre-test to 63 in the post-test, while the maximum score rose from 83 to 100. This pattern indicates that improvement occurred across the performance range rather than being limited to a small group of students.

Table 4. Descriptive statistics of pre-test and post-test scores

Statistic	Pre-test	Post-test
Mean	47.57	81.7
Median	47	83
Standard deviation	15.571	9.029
Minimum	20	63
Maximum	83	100

These descriptive results suggest that the video tutorial–based learning media were associated with better learning outcomes in horizontal-position SMAW welding. The reduction in score dispersion from pre-test to post-test further indicates that student performance became less varied after the intervention. This pattern is in line with earlier studies showing that video tutorial–based instruction can improve technical-skill performance by allowing students to observe procedures repeatedly and follow structured demonstrations more clearly than through verbal explanation alone (Anwar et al., 2024; Bobkina et al., 2025; Hafis et al., 2023; Prasetyo et al., 2024). A methodological point should also be considered. The relatively high post-test mean, together with the narrower spread of scores, may indicate some upper-end clustering. This suggests that the instrument was effective at capturing initial differences in students' performance but may have become less sensitive once most students had achieved a higher level of mastery. Although this does not weaken the main conclusion, it should be taken into account when interpreting the distribution of post-intervention performance (Clifton & Clifton, 2019).

3.2 Assumption testing

Before the main hypothesis test was performed, the distributional assumptions were examined. The results indicate that both the pre-test and post-test scores were normally distributed, as the Kolmogorov–Smirnov significance values exceeded 0.05. In addition, Levene's test yielded a non-significant result, suggesting no significant heteroscedasticity across the two measurement occasions. Although homogeneity of variance is not the principal assumption for a paired-samples t-test, it was included here as an additional diagnostic. The corresponding statistics are summarized in Table 5. Taken together, these results indicate that the dataset met the basic requirements for parametric analysis and that a paired-samples t-test could be used to examine the difference between pre-test and post-test performance.

Table 5. Assumption testing results

Test	Statistic	df	Sig.	Interpretation
Kolmogorov–Smirnov (Pre-test)	0.205	30	0.2	Normally distributed
Kolmogorov–Smirnov (Post-test)	0.132	30	0.19	Normally distributed
Levene's test	2.835	1, 58	0.098	Homogeneous variance

3.3 Effect of the intervention

The study hypothesis was tested using a paired-samples *t*-test. The analysis revealed a statistically significant difference between students' pre-test and post-test scores. When calculated as post-test minus pre-test, the mean difference was 34.13 (SD = 12.26, SE = 2.24), with a 95% confidence interval of 29.56 to 38.71. The test result was highly significant, $t(29) = 15.25$, $p < 0.001$, indicating that students performed significantly better after learning through the video tutorial–based media. The main inferential results are presented in Table 6. These results provide statistical confirmation of the improvement already observed in the descriptive analysis.

Table 6. Paired-samples t-test results

Comparison	SD	SE	95% CI	t	df	p
Post-test – Pre-test	12.258	2.238	29.556 to 38.711	15.252	29	<0.001

To complement the significance test, the effect size was estimated using Cohen's *d* for paired samples. Based on the paired-difference statistics, the effect size was very large ($d = 2.78$), indicating that the intervention had substantial practical importance in improving students' horizontal-position SMAW welding performance. According to Cohen's conventional benchmark, this value is well above the threshold for a large effect.

Taken together, these findings strengthen previous evidence that video tutorial–based learning can be especially effective in technical and procedural subjects because it supports repeated observation, clearer visualization of movement sequences, and self-paced review of critical steps (Noetel et al., 2021; Tjorven et al., 2026; Ulfaa et al., 2025). In welding instruction, these features are particularly relevant because procedural accuracy depends heavily on visual modeling, motor imitation, and sequential task execution rather than on verbal explanation alone (Assal et al., 2026; Prasetya, Fajri, et al., 2023; Vandevoorde et al., 2022).

4. Discussion

The findings show that video tutorial–based learning media were effective in improving students' mastery of horizontal-position SMAW welding. Students' post-test scores were substantially higher than their pre-test scores, the dispersion of scores decreased after the intervention, and the paired-samples t-test indicated a highly significant difference with a very large effect size. Taken together, these results suggest that the intervention was not only associated with higher average performance, but also with more consistent achievement across learners. In a vocational context where procedural accuracy and repeated observation are essential, this pattern indicates that video tutorials can support meaningful improvement in practical welding performance rather than merely increasing short-term familiarity with the task.

This result is broadly consistent with previous studies showing that video-based instruction can enhance learning outcomes in technical and skill-oriented subjects by making procedural demonstrations clearer, more repeatable, and more accessible to students (T. Ahmad, 2020; Hafis et al., 2023; Noetel et al., 2021; Prasetyo et al., 2024). It also extends earlier work in welding education, which has largely emphasized general SMAW instruction, platform-based delivery, or more technology-intensive innovations such as VR and AR, by showing that a position-specific video tutorial can be effective even in a more feasible and classroom-ready format (Chan et al., 2022; Prasetya, Fajri, et al., 2023; Prasetya, Fortuna, et al., 2023; Yunus et al., 2025). In this sense, the present study contributes more targeted evidence to the literature: the pedagogical value of digital media in welding education does not depend only on technological sophistication, but also on alignment with the procedural demands of a specific welding task.

The findings are also theoretically coherent with perspectives on multimedia and procedural learning. Video tutorials combine verbal explanation with visual demonstration, allowing students to observe sequence, movement, angle, and execution more directly than through spoken instruction alone. This matters particularly in horizontal-position SMAW welding, where learners must coordinate multiple visible and motoric actions with precision. The large improvement observed in this study supports the idea that well-structured video media can reduce unnecessary cognitive burden and help learners build procedural understanding through repeated viewing and guided practice (Barman & Jena, 2023; Gkintoni et al., 2025; Kuhlmann et al., 2024). The reduced variability in post-test scores further suggests that the tutorial may have functioned as a common instructional scaffold, helping weaker students narrow the gap with higher-performing peers.

An additional strength of the present findings lies in their internal triangulation across multiple forms of evidence. The conclusion that the intervention was effective is not based on a single indicator alone, but on the convergence of descriptive improvement, acceptable assumption testing, statistically significant pre-test–post-test differences, and a very large effect size. This statistical pattern is further reinforced by its conceptual consistency with prior research on video-supported procedural learning and with the practical logic of welding instruction, in which repeated visual modeling plays a central role in skill formation (Assal et al., 2026; Nooijen et al., 2024; Vandevoorde et al., 2022). In that sense, the study provides a coherent body of evidence that the instructional medium was pedagogically meaningful in this vocational setting.

Simultaneously, the results should be interpreted with appropriate caution. Because the study used a one-group pretest-posttest design without a control group, the observed gain cannot be attributed to the intervention with the same certainty as in a true experimental design. Repeated practice, familiarity with the task, and classroom context may also have contributed to the improvement. Even so, the magnitude of the gain and the consistency of the statistical evidence suggest that the video tutorial was likely an important contributor to students' enhanced performance. Therefore, the study offers promising initial evidence that low-cost, position-specific video tutorial media can strengthen procedural learning in welding education, while also pointing to the need for future controlled studies to confirm the robustness of this effect across broader vocational contexts.

5. Limitations and Implications

This study has several limitations that should be considered when interpreting the findings. First, it employed a pre-experimental one-group pretest-posttest design without a control group. Although this design was appropriate for obtaining initial evidence in an authentic vocational classroom, it limits the strength of causal inference because the observed improvement may also have been influenced by repeated practice, maturation, or classroom context. Second, the study involved only 30 students from a single intact class at a single vocational school, limiting the generalizability of the findings to other schools, student cohorts, or welding-training contexts. Third, although the performance assessment instrument covered preparation, process, and final result domains, the analysis was conducted at the overall-score level rather than at the subscale level. As a result, the study confirmed overall improvement, but could not determine which specific aspects of horizontal-position SMAW performance improved the most. In addition, the relatively high post-test mean suggests a possible upper-end clustering of scores, indicating that future studies may need a more discriminating instrument to capture finer post-intervention differences.

Despite these limitations, the study offers important implications for both theory and practice. From a theoretical perspective, the findings strengthen the argument that video tutorial–based learning media can serve as effective instructional scaffolds for procedural and psychomotor learning in TVET, particularly when the task requires visible sequences, coordinated movement, and repeated demonstration. The study also extends welding-education research by showing that pedagogical fit may matter more than technological complexity; in other words, a targeted and well-designed video tutorial can be pedagogically meaningful even without advanced immersive technologies. From a practical perspective, the findings suggest that vocational teachers can use video tutorials as a feasible, low-cost, and scalable instructional medium to support welding practice, especially for technically demanding tasks such as horizontal-position SMAW welding. For schools and curriculum developers, the results indicate that digital innovation in vocational education does not necessarily require high-cost infrastructure but rather instructional tools closely aligned with procedural learning needs.

6. Conclusion and Recommendations

This study concludes that video tutorial–based learning media were effective in improving students' mastery of horizontal-position SMAW welding. The intervention was associated with a substantial increase in post-test scores, reduced score dispersion, and a very large practical effect, indicating that students not only performed better after the intervention but also showed more consistent achievement as a group. These results suggest that video tutorials can support procedural skill development in welding by making demonstrations clearer, repeatable, and easier for students to review during practice-oriented learning.

Based on these findings, several recommendations can be proposed. For vocational teachers, video tutorial–based media should be integrated more systematically into welding instruction, particularly for position-specific tasks that require precise movement, angle control, and visual accuracy. For schools, support should be directed toward the development and classroom use of technically focused, accessible digital learning materials that complement workshop practice. For future research, stronger designs with control groups, larger samples, multiple schools, and domain-level analysis are recommended to confirm the robustness of the findings and identify which dimensions of welding performance benefit most from the intervention. In this way, subsequent studies can build on the present work and provide a stronger evidence base for digital pedagogy in welding education and TVET more broadly.

Author's declaration

Author contribution

Fadli Gunawan: Conceptualization, Writing Original Draft. **Bulkia Rahim:** Methodology, Data Curation. **Dori Yuvenda:** Validation. **Fathir Aspar:** Writing -Review & Editing.

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Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical clearance

The involvement of lecturers and students who are the subjects of this research is in accordance with the Helsinki Declaration.

AI statement

The author used a grammar-checking tool, namely Grammarly, to improve language clarity. The tool was not used to generate scientific content, and all text, tables, and figures were produced and verified manually by the author.

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