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The Effectiveness of the Continuous Clamping (Strongback) Method in Controlling Distortion during Welding Practical Work at the Welding Technology Workshop, Sungai Buloh Vocational College

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Abstract

Welding distortion is a persistent obstacle in vocational welding training, where students must simultaneously manage arc control, electrode angle, travel speed and workpiece stability. This action research evaluated the use of a continuous clamp (strongback) as a mechanical restraint during Shielded Metal Arc Welding (SMAW) butt-joint practicals on 6 mm carbon steel plate. Twenty-eight Malaysian Vocational Diploma students in the Welding Technology programme at Sungai Buloh Vocational College took part, selected by purposive sampling. The study followed one Kemmis and McTaggart cycle of planning, action, observation and reflection. Data were gathered through direct distortion measurement in millimetres, a structured observation checklist, a post-intervention questionnaire, photographic documentation and assessment of finished joints, and were analysed using descriptive statistics and thematic analysis. Mean measured distortion fell from 5.2 mm before the intervention to 1.9 mm after it, a reduction of approximately 63.5 per cent, while the proportion of students in the high-distortion category fell from 57.1 to 10.7 per cent. Observation further indicated more consistent compliance with the recommended welding procedure, particularly in maintaining restraint until the workpiece had cooled. Because the design used a single intact group with no control group and no inferential testing, these results describe change within one cohort rather than establishing a causal effect. The findings nonetheless suggest that a low-cost mechanical aid can support dimensional accuracy and procedural discipline in vocational welding workshops, and they provide a defensible basis for a larger controlled study.

Keywords: Welding distortion, strongback, mechanical restraint, shielded metal arc welding, action research, vocational education

1. Introduction

Welding is a fundamental manufacturing process widely used in the construction, automotive, shipbuilding, oil and gas, and metal fabrication industries. In Malaysia's Technical and Vocational Education and Training (TVET) system, welding skill is one of the core competencies that is assessed against performance standards of work rather than on theoretical knowledge alone. Assessment in TVET as a whole is dominated by competency-based approaches that require students to demonstrate mastery of skills in practice (M. Yusop et al., 2022). The quality of practical workshop output is therefore not merely evidence of learning; it is also the principal measure of a student's readiness to enter the workforce.

Among the various welding processes, Shielded Metal Arc Welding (SMAW) remains the process most widely taught in vocational colleges. This is due to its low equipment cost, its high versatility across welding positions, and the continuing industry demand for certified SMAW welders. At the same time, SMAW is also the process that demands the most manual control from the operator, since arc length, electrode angle and travel speed depend entirely on the dexterity of the student's hand.

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One of the most common welding defects is distortion, that is, the permanent deformation that results from uneven thermal expansion and contraction during the heating and cooling cycle. When the base metal is heated locally, the hot region tries to expand but is restrained by the surrounding cold metal, producing compressive plastic strain; during cooling, the region contracts and pulls the structure towards it (Kou, 2003; Messler, 1999). The result is angular distortion, transverse shrinkage, longitudinal shortening and, in thin plate, buckling. In butt-joint work, angular distortion is the most conspicuous form and the one most easily detected by students (American Welding Society, 2018).

The magnitude of distortion is influenced by several interrelated variables. Analytical models show that angular distortion is directly proportional to the area of the weld bead and inversely proportional to the square of the plate thickness and to the degree of restraint applied (Seong et al., 2020). Welding sequence also has a measurable effect: a study of structural steel butt joints found that a symmetrical sequence produced the lowest angular distortion compared with other sequences (Afonso et al., 2022). In the SMAW process specifically, multi-response optimisation on carbon steel has shown that root gap, groove angle, electrode diameter and preheating all significantly influence angular distortion (Qazi et al., 2020). This means that any attempt to evaluate a distortion-control method should hold the other variables constant as far as possible.

A variety of approaches have been developed to reduce welding distortion. A systematic review of mitigation methods groups them into four families: control at the joint design stage (grooving, tack welds, preheating, pre-bending), control of process parameters, optimisation of welding sequence, and in-process mechanical and thermal balancing, which includes external restraint and thermal tensioning (Wu & Kim, 2020). Industry practice guides list similar methods and emphasise that distortion control is most effective when it is planned before the arc is struck, rather than corrected after welding is complete (James F. Lincoln Arc Welding Foundation, 2000; Jeffus, 2016).

Within the family of mechanical control, external restraint by means of clamps, fixtures or jigs is the most practical method for a workshop environment. Experimental and numerical studies show that clamp configuration — its position, its stiffness and its release time — changes not only the magnitude of distortion but also its pattern (Schenk et al., 2009). Optimisation of jig layout on large structures has likewise confirmed that systematically planned restraint significantly reduces measured deformation (Ma & Huang, 2017). The study closest to the context of the present research found that releasing the clamps after the workpiece had cooled, compared with releasing them while it was still hot, reduced angular and bending distortion by up to approximately 70 per cent, and that placing the clamps closer to the weld line also produced a measurable reduction (Gharib et al., 2019).

However, the same literature also identifies the limits of the effectiveness of restraint. External restraint has been found to be less able to prevent buckling in very thin plate, although it is effective in reducing out-of-plane deformation in thicker plate (Liang & Deng, 2022), and restraint alone, without a symmetrical welding sequence, is insufficient to control buckling in thin-plate joints (Sun & Dilger, 2023). More importantly, restraint does not eliminate strain energy; rather, it transfers it into residual stress locked within the joint (Park et al., 2023), and restrained configurations are known to be more prone to the development of high residual stress (Falodun et al., 2025). These limitations need to be stated openly in any educational study that promotes the use of clamps.

From a TVET perspective, the development of welding proficiency among Malaysian vocational college students still faces recurring challenges. A case study of graduates of an SMAW 3G-position upskilling programme at a vocational college found that participants consistently asked for more hands-on experience, better access to equipment and more thorough safety briefings (Mohd. Ahyan et al., 2024). Studies in other vocational settings have also shown that the formation of 3G welding competency failed to be achieved not because of weaknesses in the students, but because of workshop resource constraints such as an excessively low machine-to-student ratio (Bahora & Mujiyono, 2019). An intervention that is inexpensive, easy to build and can be provided for every student therefore has high practical value in this context.

At the Welding Technology Workshop, Sungai Buloh Vocational College, welding distortion has been consistently identified as one of the main issues affecting the quality of students' work. Teaching observations found that students frequently remove the clamps before the workpiece has truly cooled, produce tack welds that are too small or too widely spaced, and do not reposition the plates after the first pass. As a result, the butt joints produced often fail to meet the prescribed dimensional tolerances, and students have to repeat the work, which cuts into the limited practical time.

From the perspective of learning theory, this situation can be understood through cognitive load theory. Working memory has a very limited capacity, and effective instructional design works by reducing load that is unrelated to the target learning (Sweller, 2020). During SMAW practice, novice students must manage arc length, electrode angle, travel speed and workpiece position simultaneously. When the stability of the workpiece is ensured mechanically, one of these sub-tasks is removed from the working-memory load, thereby freeing capacity for the tasks that are genuinely the target of learning. The same principle also supports the gradual withdrawal of support as students become more proficient (Sweller et al., 2019).

In addition, the stability of the workpiece also affects the quality of practice itself. Practice produces improvement in skill only when it involves repeated attempts that are purposeful, guided and accompanied by corrective feedback (Ericsson & Harwell, 2019). Students who must repeatedly reset a plate that has shifted will obtain fewer successful welding attempts within the same practical session. The second dimension is procedural compliance: a workshop safety study in Malaysia found a marked gap between students' knowledge of the rules and their actual practice, with negligence identified as one of the main causes of accidents (Vengidason et al., 2021). This means that the target of the intervention is not only procedural knowledge, but also procedural compliance behaviour.

Low-cost teaching-aid innovations have a promising record in Malaysian TVET. A structural teaching kit built specifically for construction technology students was judged suitable in design, materials and function by lecturers at two vocational colleges (Yee et al., 2021), while an electro-pneumatic training device and an aquaponic mini model were each developed as alternatives to expensive commercial equipment and validated by panels of TVET experts (Lutfi et al., 2022; Saim et al., 2021). By contrast, a review of welding-instruction innovations found the field to be dominated by virtual reality, augmented reality and digital simulation technologies (Ahmad et al., 2024) — solutions that are costly and difficult to scale in vocational colleges.

This is where the research gap lies. The engineering literature provides strong evidence that mechanical restraint alters welding distortion, but that evidence was obtained from laboratory samples, instrumented fixtures and finite element simulation, not from students' hands in a time-limited practical session. The TVET education literature, for its part, provides evidence that low-cost physical teaching aids can support practical learning, but its focus is on models, kits and training devices, not on a restraint device that forms part of the work procedure itself. To the best of the researchers' knowledge, no study has yet evaluated the use of a continuous clamp as a teaching practice in a vocational welding workshop. This study seeks to bridge that gap.

Accordingly, this study employs the Kemmis and McTaggart (1988) Action Research Model to evaluate the implementation of a continuous clamp (strongback) as a mechanical restraint method during SMAW practical sessions. Specifically, the objectives of this study are to:

(i) determine the level of welding distortion before the implementation of the continuous clamp (strongback);
(ii) implement the use of the continuous clamp (strongback) as an intervention in SMAW practical sessions;
(iii) evaluate the change in the level of welding distortion after the implementation of the intervention;
(iv) examine changes in students' understanding of distortion control and workpiece restraint techniques; and
(v) determine whether the percentage of welded joints that meet the prescribed dimensional tolerance increased after the intervention.

2. Methodology

2.1 Research Design

This study employed an action research design based on the Kemmis and McTaggart (1988) Model, which consists of four iterative phases, namely planning, action, observation and reflection. The model was chosen because it enables educators to systematically identify problems encountered during teaching and learning, implement suitable interventions, evaluate the changes that result, and continuously improve teaching practice. This study carried out one full cycle of the model.

Action research is suited to educational contexts because it allows practitioners to improve their professional practice while generating practical knowledge through systematic reflection (Stringer, 2014). At the same time, the limitations of this approach are acknowledged: a study of teachers' action research practice in Malaysia reported heavy workloads, difficulty in collecting data alone, and the risk of bias when practitioners become researchers of their own practice (Moktar et al., 2025). These limitations were taken into account when interpreting the findings of this study.

The issue identified was the occurrence of excessive distortion during Shielded Metal Arc Welding (SMAW) practical sessions involving butt joints in 6 mm thick carbon steel. The intervention implemented was the use of a continuous clamp (strongback) throughout the welding process to minimise workpiece movement during heating and cooling. The resulting changes were evaluated by comparing distortion measurements before and after implementation, supported by qualitative observation of students' work practices and learning behaviour. It should be emphasised that this design did not involve a control group; it describes change within one intact group.

2.2 Research Participants

This study involved 28 students of the Malaysian Vocational Diploma (Diploma Vokasional Malaysia, DVM) from the Welding Technology Programme at Sungai Buloh Vocational College, Selangor, Malaysia.

Purposive sampling was used because the selected participants had completed basic SMAW practical training and showed recurring distortion problems when welding carbon steel butt joints. This group of students was therefore a suitable sample for evaluating the implementation of the strongback in an authentic practical context. Permission to conduct the study was obtained from college management, and student participation was voluntary, with the assurance that data would be reported anonymously and would not affect their course assessment.

Before the intervention was implemented, all participants underwent initial observation and distortion measurement to obtain baseline performance data. Table 1 presents the information on the study and the participants involved.

Table 1. Study and Participant Information

Item	Description
Institution	Sungai Buloh Vocational College
Programme	Malaysian Vocational Diploma (DVM) – Welding Technology
Participants	28 students
Welding Process	Shielded Metal Arc Welding (SMAW)
Material	Carbon Steel Plate (6 mm)
Study Location	Welding Technology Workshop

2.3 Research Instruments

Five instruments were used to obtain comprehensive data on the implementation of the strongback. The use of multiple instruments enhances data reliability through triangulation and allows the quantitative and qualitative aspects to be evaluated thoroughly. This approach is consistent with competency-based assessment practice in TVET, which evaluates skill mastery through multiple sources of evidence rather than a single test (M. Yusop et al., 2022). The instruments used are summarised in Table 2.

Table 2. Research Instruments

Instrument	Purpose
Observation checklist	To observe students' welding practice and compliance with procedures
Distortion measurement	To measure workpiece deformation (mm)
Questionnaire	To obtain students' perceptions
Photographic documentation	To compare the condition of the workpiece before and after the intervention
Assessment of students' work	To evaluate the quality of the welded joints

2.3.1 Observation Checklist

A structured observation checklist was developed to record students' level of compliance with the recommended welding procedures throughout the practical sessions. The aspects observed included workpiece preparation, strongback installation, tack welding practice, workpiece alignment, welding sequence, and the procedure for removing the clamps after the cooling process. The checklist was reviewed by a senior lecturer of the Welding Technology Programme to ensure its content validity.

2.3.2 Distortion Measurement

The primary quantitative data were obtained through direct distortion measurement. Measurements were made using a steel rule, a combination square and a vernier caliper to determine the deviation from the original alignment of the workpiece. Physical measurement was chosen over simulation-based estimation because the accuracy of computational methods for estimating angular distortion remains a matter of concern in the literature (Zhu et al., 2019), and because it suited the equipment available in the workshop.

Readings were recorded in millimetres (mm) before and after the implementation of the strongback intervention, and the group mean value was used as the comparative measure. The individual reading of each participant was not recorded separately in this study; only the category distribution and the group mean value were available for analysis.

2.3.3 Questionnaire

A short post-intervention questionnaire was distributed to obtain students' perceptions of the usefulness of the strongback, their level of understanding of distortion control, and their confidence in applying the technique during welding practical sessions. The questionnaire data are self-reported and are interpreted as participant feedback, not as an objective measure of skill.

2.3.4 Photographic Documentation

Photographic documentation was collected before, during and after the implementation of the intervention. These photographs provide visual evidence of workpiece alignment, clamp position and the overall condition of the weld, and were used to support the measurement data.

2.4 Research Procedure

The implementation of the intervention followed the four phases of the Kemmis and McTaggart (1988) Action Research Model.

Phase 1: Planning

The planning phase involved identifying the causes of welding distortion through workshop observation and initial distortion measurement. The findings showed that many students failed to maintain workpiece restraint throughout the welding process, particularly by removing the clamps before the workpiece had cooled. In this phase, the strongback design was also finalised and fabricated from workshop scrap steel, and a written work procedure was prepared to ensure uniform installation for all participants.

Phase 2: Action

During the action phase, students were briefed on the mechanism of distortion, the correct method of installing the strongback, tack welding techniques and the recommended welding procedure. The continuous clamp was then used throughout the practical sessions, and students were required to keep it in place until the workpiece had cooled to room temperature. Other welding parameters — electrode type and diameter, root gap, groove angle and welding sequence — were kept uniform for all participants as far as workshop conditions allowed.

Phase 3: Observation

Students' work practices were systematically observed throughout the welding process using the prepared checklist. Distortion measurements, the level of compliance with welding procedures and student feedback were recorded during this phase.

Phase 4: Reflection

Finally, the quantitative and qualitative findings were analysed to evaluate the changes that had occurred. The reflection process focused on changes in students' practical competency, the constraints encountered during implementation, and suggestions for improvement in the next action research cycle.

2.5 Data Analysis

Quantitative data were analysed using descriptive statistics comprising frequency, percentage, mean value and percentage reduction. Inferential tests were not conducted because the study did not involve a control group and the individual readings of each participant were not recorded separately.

The percentage reduction in distortion was calculated using the following equation:

$$\textit{Reduction (\%)} = [(\textit{Distortion Before} - \textit{Distortion After}) \div \textit{Distortion Before}] \times 100 \qquad (1)$$

Qualitative data obtained from observation, the questionnaire and photographic documentation were analysed thematically to identify changes in learning behaviour, work practices and students' understanding of distortion control after the intervention was implemented.

3. Findings

The changes that occurred after the implementation of the continuous clamp (strongback) were evaluated by comparing students' welding performance before and after the intervention. The findings are presented using descriptive statistics supported by visual evidence obtained throughout the study.

3.1 Initial Observation

Before the intervention was implemented, initial observation was carried out to determine the level of welding distortion among the participants. The observation showed that distortion was one of the defects most frequently encountered in students' butt-joint welding practice. Most students focused on producing a neat-looking weld bead, but paid less attention to workpiece restraint and distortion-control techniques.

In addition, several unsuitable work practices were identified, including removing the clamps before the workpiece had truly cooled, producing insufficient tack welds, and poor workpiece alignment. These practices are consistent with the pattern reported in the literature, namely that clamp release time and the distance of the clamps from the weld line have a measurable effect on angular and bending distortion (Gharib et al., 2019).

3.2 Level of Distortion Before the Intervention

Table 3 shows the distribution of welding distortion levels recorded before the implementation of the continuous clamp (strongback).

Table 3. Level of Distortion Before the Intervention

Distortion Level	Number of Students	Percentage (%)
High	16	57.1
Moderate	8	28.6
Low	4	14.3
Total	**28**	**100**

The results in Table 3 show that the majority of participants experienced a high level of distortion before the intervention was implemented. More than half of the students (57.1 per cent) produced welded joints with excessive distortion, while only 14.3 per cent achieved a low level of distortion. The mean distortion recorded during the initial assessment was 5.2 mm.

3.3 Implementation of the Continuous Clamp (Strongback)

The intervention involved the continuous use of the strongback throughout the entire welding process, from workpiece preparation until the cooling process was complete. Before the practical sessions were conducted, students were given a demonstration and guidance on the correct method of installing the strongback, suitable tack welding techniques and the recommended workpiece restraint procedure.

Throughout the intervention, students were required to keep the strongback in place until the welded joint had truly cooled to room temperature. This procedure aimed to minimise workpiece movement caused by thermal expansion and contraction during the welding process.

3.4 Observations during the Intervention

The checklist data showed a clear change in students' welding practice. Most students complied with the recommended procedures more consistently, through more precise workpiece alignment, maintaining adequate clamping pressure, and avoiding removing the clamps too early. Based on the questionnaire feedback, students also reported a better understanding of the principles of distortion control and greater confidence in applying the procedures. This feedback is self-reported and was not verified through a separate knowledge test.

3.5 Visual Comparison of Welded Joints

Figure 1 shows examples of welded joints produced before the implementation of the continuous clamp (strongback). The photographs show the marked distortion and deformation of the workpieces after the welding process.

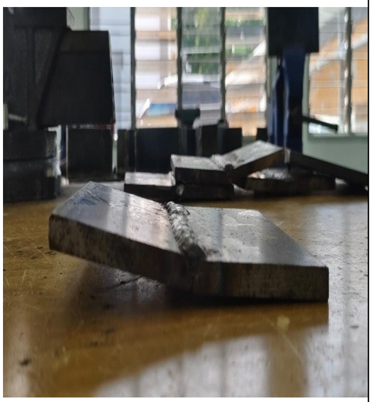
NO	FRONT VIEW	TOP VIEW	SIDE VIEW
1.			
2			
3			

Figure 1. Example of a welded joint without the use of a strongback

The welded joints shown in Figure 1 exhibit marked deformation, particularly in the alignment of the plates. This visual observation is consistent with the initial distortion measurements obtained before the intervention was implemented.

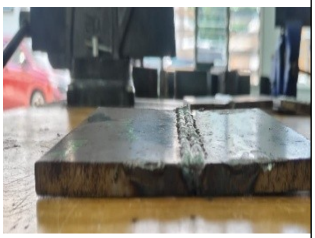
NO	FRONT VIEW	TOP VIEW	SIDE VIEW
1			
2			
3			

Figure 2. Example of a welded joint after using a strongback

Compared with Figure 1, the welded joints shown in Figure 2 display better dimensional stability and a marked reduction in deformation. The workpieces remained better aligned throughout the welding process. It should be noted that these photographs are selected examples and serve as supporting evidence, not as a measure representative of the whole group.

3.6 Level of Distortion After the Intervention

Table 4 summarises the levels of welding distortion recorded after the implementation of the continuous clamp (strongback).

Table 4. Level of Distortion After the Intervention

Distortion Level	Number of Students	Percentage (%)
High	3	10.7
Moderate	7	25.0
Low	18	64.3
Total	**28**	**100**

The findings in Table 4 show a marked change in students' welding performance after the intervention was implemented. The percentage of students with high distortion fell from 57.1 per cent to 10.7 per cent, while the percentage of students producing welded joints with low distortion rose from 14.3 per cent to 64.3 per cent.

3.7 Comparison of Mean Distortion

Mean distortion fell from 5.2 mm before the intervention to 1.9 mm after the intervention, a reduction of approximately 63.5 per cent. This value is a comparison of group means; the standard deviation, inferential tests and effect size cannot be reported because the individual reading of each participant was not recorded separately.

3.8 Overall Comparison

Table 5 compares the overall welding performance before and after the implementation of the intervention.

Table 5. Comparison Before and After the Intervention

Item	Before	After
Mean Distortion (mm)	5.2	1.9
High Distortion	16	3
Moderate Distortion	8	7
Low Distortion	4	18
Reduction (%)	–	63.5

The comparison in Table 5 shows a consistent change in the same direction for all the indicators measured. Mean distortion decreased by 63.5 per cent, the number of students in the high-distortion category fell from 16 to 3, and the number in the low-distortion category rose from 4 to 18. Because this study did not involve a control group, these changes are presented as a description of the group's performance before and after the intervention, and not as evidence that the intervention was the sole cause of the change.

4. Discussion

This study evaluated the use of the continuous clamp (strongback) as a mechanical restraint method for controlling welding distortion during SMAW practical sessions among Malaysian Vocational Diploma students. Measured mean distortion fell from 5.2 mm to 1.9 mm, a reduction of approximately 63.5 per cent, while the percentage of students in the high-distortion category fell from 57.1 per cent to 10.7 per cent. It must be emphasised at the outset of this discussion that these figures describe descriptive change within one intact group and are not the result of inferential testing against a control group. These findings are therefore interpreted as an encouraging preliminary indication, and not as causal evidence.

The direction of the observed change is consistent with the physical mechanism that has been documented in the welding engineering literature. Angular distortion in butt joints arises from the plastic strain gradient across the plate thickness, and analytical models show that its magnitude is inversely proportional to the degree of restraint applied (Seong et al., 2020). External restraint does not simply hold the plates in position; it alters the strain distribution itself, so that different clamp configurations produce not only different magnitudes but different patterns of distortion (Schenk et al., 2009). Studies of large structures likewise show that systematically planned restraint layouts reduce measured deformation (Ma & Huang, 2017). In the context of this study, the uniform use of the strongback by all participants meant that the degree of restraint became a controlled variable, rather than being left to vary according to each student's improvisation.

The procedural element that was probably the most decisive was not the presence of the clamp itself, but the length of time it was kept in place. In this intervention, students were required to keep the strongback in position until the joint had cooled to room temperature. This practice has specific empirical support: experimental and numerical studies found that releasing the fixture after the workpiece has cooled, compared with releasing it while still hot, reduces angular and bending distortion by up to approximately 70 per cent, and also showed that bringing the clamps closer to the weld line has a measurable reducing effect (Gharib et al., 2019). Initial observation in this study found that students often removed the clamps before the workpiece had cooled; hence, a considerable part of the recorded change probably stems from the change in how the tool was used, and not solely from the presence of the tool.

At the same time, these findings cannot be interpreted as evidence that mechanical restraint solves the distortion problem entirely. Computational studies show that external restraint is less able to prevent buckling in very thin plate, although it effectively reduces out-of-plane deformation in thicker plate (Liang & Deng, 2022), and that restraint alone, without a symmetrical welding sequence, is insufficient to control buckling (Sun & Dilger, 2023). More importantly, restraint transfers strain energy into residual stress locked within the joint (Park et al., 2023), and restrained configurations are indeed more prone to the development of high residual stress (Falodun et al., 2025). This study measured only visible geometric deformation and did not assess residual stress. The claim that can be made, therefore, is that the joints became more dimensionally accurate, not that they became better in every respect.

Beyond dimensional accuracy, the intervention was also related to how students allocated their attention while working. Working memory has limited capacity, and effective instructional design works by removing load that is unrelated to the target learning (Sweller, 2020). When the stability of the workpiece is ensured mechanically, students no longer need to monitor plate position while controlling the arc, which frees capacity for electrode angle and travel speed. The second effect concerns the quantity of practice: skill improvement requires repeated, purposeful attempts accompanied by corrective feedback (Ericsson & Harwell, 2019), and students who do not have to repeatedly reset the plate obtain more such attempts within the same practical period. Both mechanisms are consistent with workshop observations, but it must be stressed that this study did not measure cognitive load directly and that these explanations remain interpretive.

The clearest change in the observational data was procedural compliance. Before the intervention, students were found to know the correct procedure but did not practise it consistently — the same pattern reported in a workshop safety study in Malaysia, which found that students tend to ignore rules even when they know them, with negligence being among the main causes of accidents (Vengidason et al., 2021). The presence of the strongback works as a tangible procedural cue: it creates a step that must be carried out before the arc is struck and a step that must be waited for before the work is considered complete. In other words, the tool structures the sequence of work, and does more than merely hold the metal.

In terms of practical implications, the main advantage of this approach is its cost. A review of welding-instruction innovations shows that the field is dominated by virtual reality, augmented reality and digital simulation (Ahmad et al., 2024), which are solutions that are difficult to scale when budgets are limited. By contrast, experience with teaching-aid innovation in Malaysian TVET shows that low-cost, self-built physical devices can be validated as suitable in design and function by lecturers and expert panels (Lutfi et al., 2022; Saim et al., 2021; Yee et al., 2021). The strongback in this study was fabricated from workshop scrap steel and can be provided for every workstation. This is important because resource constraints, and not student weakness, are often identified as a major barrier to the development of welding competency (Bahora & Mujiyono, 2019; Mohd. Ahyan et al., 2024).

Several limitations of the study need to be stated clearly. First, the study design used a single intact group of 28 students without a control group, so the recorded change cannot be separated from the effects of repeated practice, skill maturation or the additional attention received by participants during the intervention. Second, the analysis was limited to descriptive statistics; the mean, the standard deviation for each participant, inferential tests and effect sizes were not reported, and the 63.5 per cent reduction therefore cannot be interpreted as statistically significant. Third, the researcher was the lecturer who taught the group and was also the observer and assessor of the work, thereby creating a risk of researcher bias — a limitation that has indeed been identified in teachers' action research practice in Malaysia, alongside workload burdens and the difficulty of collecting data alone (Moktar et al., 2025). Fourth, the study was conducted at a single site, using one type of joint (butt), one plate thickness (6 mm) and one process (SMAW), so the generalisability of the findings is limited. Fifth, the study did not measure the persistence of the effect after the strongback was withdrawn, so it is not known whether students retain dimensional accuracy when working without it.

These limitations directly determine the direction of further research. Future studies should use a quasi-experimental design with a control group to separate the effect of the intervention from the effect of repeated practice, and should report the mean, standard deviation, inferential tests and effect size for each distortion measure. Measurement should preferably follow a standard protocol and be verified by an independent second assessor to reduce researcher bias, given that the accuracy of the measurement method is itself a matter of concern in welding distortion research (Zhu et al., 2019). Studies should also be extended to T-joints and lap joints, to different plate thicknesses, and to the GMAW and GTAW processes, since the degree of restraint interacts with thickness and welding sequence (Afonso et al., 2022; Sun & Dilger, 2023). Finally, a design involving the gradual withdrawal of support — students using the strongback in the early stage and then working without it — would answer the question of whether the tool builds skill or merely substitutes for it, in line with the principle of guidance fading in instructional design (Sweller et al., 2019).

5. Conclusion

This action research investigated the use of the continuous clamp (strongback) as a mechanical restraint method to control welding distortion among 28 Malaysian Vocational Diploma students at the Welding Technology Workshop, Sungai Buloh Vocational College, through one cycle of the Kemmis and McTaggart Model.

The descriptive findings show that measured mean distortion fell from 5.2 mm before the intervention to 1.9 mm after it, a reduction of approximately 63.5 per cent, while the percentage of participants in the high-distortion category fell from 57.1 per cent to 10.7 per cent and the percentage in the low-distortion category rose from 14.3 per cent to 64.3 per cent. Observation data showed more consistent compliance with the recommended work procedure, particularly in maintaining restraint until the workpiece had cooled, while questionnaire feedback showed that students reported a better understanding of the distortion mechanism.

Because this study used a single intact group without a control group and reported only descriptive statistics, the findings do not establish a causal relationship. What can be concluded is that a consistent change in the same direction was recorded in one cohort, and that the direction of this change is consistent with the mechanism of mechanical restraint that has been documented in the welding engineering literature.

The main contribution of this study is practical. It describes a low-cost intervention that can be fabricated from workshop scrap material, can be provided for every workstation, and can be integrated into existing practical procedures without changing the curriculum or requiring the procurement of new equipment. In the context of vocational colleges facing constraints in equipment and practical time, these characteristics have real value.

The researchers recommend that the use of the continuous clamp be retested through a quasi-experimental design with a control group and reporting of inferential statistics, extended to other joint types, plate thicknesses and welding processes, and evaluated in terms of the persistence of the effect after support is withdrawn, before any more general claims of effectiveness are made.

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Conflict of Interest

The researchers declare that there is no conflict of interest regarding the research, authorship or publication of this article.

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