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TRAINING FOR WELDING WORKSHOP WORKERS TO BECOME FIRE ARTISTS

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Abstract

This community service program was developed to enhance the technical and creative competencies of welding workshop workers through integrated training in welding techniques and computer-aided design. Many welders in the region rely on self-taught skills, which often limits their ability to meet modern industry standards, particularly in precision work and design innovation. To address this gap, a three-day participatory training program was implemented, combining instruction in SMAW, GMAW, and GTAW welding processes with introductory CAD and simulation practices using SketchUp, AutoCAD, and Ansys. The results demonstrate significant improvements in participants' abilities: half of the trainees successfully learned to model and simulate simple structures digitally, while all participants achieved basic proficiency in GTAW welding despite most having no prior experience. A structured case study further revealed increased skill integration, although varied progress suggested differences in digital adaptation. Overall, the program effectively broadened the welders' technical capabilities, enhanced workplace safety awareness, and encouraged creativity in metal fabrication. This initiative highlights the importance of continuous upskilling for informal workers and shows the potential of merging digital literacy with hands-on craftsmanship to produce more competent and innovative "fire artists" in the welding sector.

Keywords: *Welding Skills Training, Computer-Aided Design (CAD), GTAW/TIG Welding Competency, Digital Design Integration, Vocational Skill Enhancement*

1. INTRODUCTION

Welding workshops play a vital role in supporting the infrastructure and construction needs of the community. From building household furniture to constructing gates, fences, canopies, and supporting small to medium enterprises, welding services are indispensable in daily life. These workshops serve not only as service providers but also as enablers of functional and aesthetic improvements in urban and rural environments [1]. The ability of welding shops to adapt to increasingly diverse customer demands reflects their importance in the broader scope of community development.

However, the majority of welders working in these workshops often acquire their skills through self-learning or hands-on practice, without undergoing any form of standardized vocational training [2]. While this autodidactic approach may suffice for basic tasks, it often leads to inconsistencies in quality, safety risks, and limitations in design capability. The lack of formal education also hinders welders from accessing more sophisticated technologies and design tools, limiting their professional growth and the competitiveness of the workshops they serve.

To address this gap, standardized training programs are essential, not only to improve welding skills but also to equip welders with the ability to interpret

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technical drawings, adhere to quality standards, and explore creative design possibilities. Incorporating design software such as SketchUp or AutoCAD in the training process enables welders to visualize and model structures like furniture, canopies, railings, and artistic metalworks with greater precision. This integration of craftsmanship and creativity transforms them into what can be called *"fire artists"*, capable of producing not only structurally sound products but also visually appealing and customized designs [3].

In response to this need, the Community Service Team from the Research Group of Metals Processing & Technology (RG Metals), Faculty of Engineering, Universitas Sebelas Maret (UNS), conducted a specialized training program. The program involved hands-on welding skill enhancement and software-based design training tailored for welding workshop practitioners across the Solo Raya region. The goal was to empower local welders with both technical and digital design competencies, bridging the gap between traditional practices and modern industry demands.

2. METHOD

This community service program was designed and implemented using a participatory training approach, combining theoretical instruction, hands-on practice, and mentoring. The program took place over a three-day period and was conducted at the Metal Fabrication Laboratory, Faculty of Engineering, Universitas Sebelas Maret (UNS), as well as at selected welding workshops within the Solo Raya region.

2.1 Participant Selection

Participants were selected through collaboration with local welding workshop associations and community leaders. A total of 10 participants from various welding shops across Solo Raya were recruited, with a focus on those who had not received formal vocational training but had practical welding experience.

2.2 Training Modules

The training was divided into two main modules:

a. Welding skills enhancement

This module focused on standard welding techniques based on safety procedures, quality assurance, and productivity. It included theoretical material on welding joints, types of electrodes, and defect prevention, followed by practical sessions on flat, vertical, and overhead welding using Shielded Metal Arc Welding (SMAW) and Gas Metal Arc Welding (GMAW).

b. Computer-Aided Design (CAD) for metal structures

In this module, participants were introduced to basic 2D and 3D design concepts using software such as SketchUp and AutoCAD. Participants learned to design furniture, canopies, railings, grilles, and other structural products relevant to their work. Each participant was guided to create a digital model and then fabricate a prototype based on their own design. The design that will be used as the training material is shown in Figure 1.

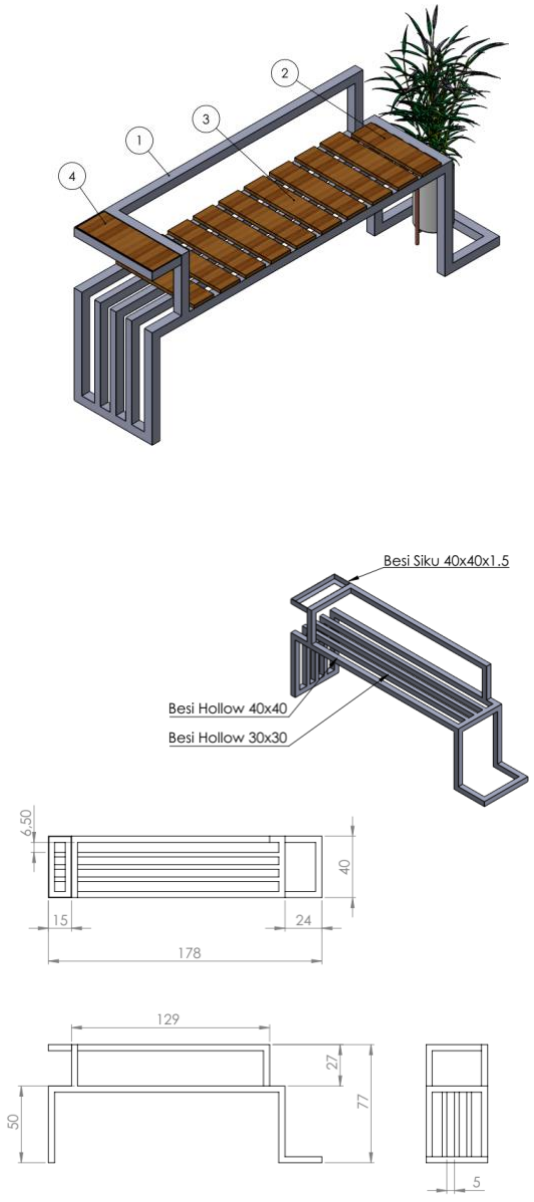

Figure 1. The design for training

2.3 Mentoring and Evaluation

During the training, participants were mentored by experts from the RG Metals research group, including academic staff and technicians. Evaluation was conducted through pre- and post-training assessments that measured welding technique accuracy, safety

awareness, and design skills. In addition, participant feedback was collected via questionnaires to assess satisfaction, learning outcomes, and applicability to their workplace.

2.4 Follow-up and Disemination

To ensure sustainable impact, the team distributed training handbooks and video tutorials to each participant. A WhatsApp group was created to serve as a communication and support forum after the training. Selected participants were also invited to UNS for advanced training and further collaborative projects.

3. RESULTS AND DISCUSSION

The implementation of the training program yielded significant improvements in both the digital design capabilities and welding skills of the participating welders. The results are presented in both quantitative and qualitative terms, reflecting the progress made during the short yet intensive training period.

3.1 Improvement in software design competency

Figure 2 presents the design training activities conducted using *Ansys* software. Figures 2(a)–2(c) do not illustrate specific tasks but rather depict various perspectives of the training session. At the outset, none of the ten participating welders possessed prior experience with engineering design software such as *Ansys*, which constrained their capability to plan, simulate, and assess the structural performance of fabricated components. Following completion of the design module, however, 50% of participants (5 out of 10) demonstrated the ability to utilize *Ansys* for modeling and simulating simple structures such as benches, gates, and frames. This achievement signifies a considerable learning gain, given the participants' initially limited exposure to computer-aided design and simulation tools.

The incorporation of software-based training not only introduced the welders to contemporary engineering design practices but also fostered a transition from conventional trial-and-error fabrication to a more analytical and systematic design approach. The enhanced capability to visualize stress distributions, material responses, and dimensional accuracy is expected to improve both the safety and creativity of future projects, ultimately supporting the development of *"fire artists"* who integrate functionality with aesthetic expression [3].

Figure 2. The design training activities conducted using *Ansys* software

3.2 Mastery of GTAW Welding Technique

Figure 3 illustrates the welding training activities conducted using the Tungsten Inert Gas (TIG) welding process. Of the ten participants, eight had no prior experience with Gas Tungsten Arc Welding (GTAW). Following a series of intensive practical sessions and guided mentoring, all participants (100%) successfully acquired fundamental GTAW competencies, including electrode manipulation, arc stability control, and techniques for welding thin materials. This outcome highlights the effectiveness of the experiential, hands-on training approach in accelerating skill development, particularly when complemented by real-time feedback from instructors and collaborative peer-learning interactions.

The mastery of GTAW is critically important for high-precision and high-aesthetic applications such as stainless-steel furniture, ornamental gates, and thin aluminum components. Proficiency in this process substantially enhances the technical capacity and value-added potential of local welding workshops [4-6], enabling them to engage in more sophisticated and visually refined fabrication projects. Consequently, this training initiative not only improved participants' technical skills but also contributed to the advancement of local manufacturing capabilities and craftsmanship quality.

Figure 3. The Tungsten Inert Gas (TIG) welding training activities

3.3 Case Study: Park Bench Design Exercise

To evaluate the participants' ability to apply design concepts and manage time effectively, a structured case study was conducted. Each participant was tasked with designing a park bench based on a reference image, including dimensional specifications and structural layout, using the CAD software introduced during the training. The allotted time for completion was 60 minutes. Figure 4 presents the sequence of activities demonstrating the integration of design and TIG welding

training outcomes: Figure 4(a) shows the material cutting process according to the designed dimensions, Figure 4(b) depicts the welding process, and Figure 4(c) displays the completed park bench produced as part of the case study.

The case study results were as follows:

(a) Three participants (30%) successfully completed high-quality, well-dimensioned designs that demonstrated a solid understanding of both structural integrity and aesthetic considerations.
(b) Two participants (20%) completed their designs but required revisions related to proportional accuracy and joint positioning.
(c) Five participants (50%) were unable to finish the task within the allocated time, primarily due to limited experience with digital design tools and slow adaptation to the software interface.

These findings highlight both the progress achieved and the challenges that remain. Although half of the participants struggled to complete the design within the set timeframe, the fact that 50% were able to produce full or partial designs represents substantial progress achieved within only a few training sessions. With extended practice duration or additional follow-up workshops, it is anticipated that most participants would reach a higher level of design proficiency and confidence in integrating digital design with fabrication processes.

Figure 4. Performing a structured case study

4. DISCUSSION

The results highlight the transformative potential of targeted, skill-based training that blends digital literacy and practical welding skills. The incorporation of software such as Ansys and CAD platforms bridges the gap between traditional welding and modern metalcraft. Furthermore, hands-on practice with GTAW allows participants to expand their service offerings and enter markets requiring precision welding.

This training approach aligns with the principles of lifelong learning and upskilling for informal sector workers, who often operate outside formal education systems but contribute significantly to community development [7,8]. The methodology also emphasizes active learning and project-based assignments, which have been shown to be more effective than passive instruction in vocational settings [9,10].

Nonetheless, the varying levels of participant progress suggest that future programs should consider differentiated instruction, allowing more time for slower learners, and follow-up mentoring to ensure sustained impact. Additional collaboration with software providers or vocational institutions may further enhance the scalability of such initiatives.

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