Determining the Professional Development Needs of Students Using an Augmented Reality Welding System

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Introduction

The fabrication skill of welding is crucial in agricultural mechanics as well as many other industries (Stone et al., 2011a). As the shortage of skilled welders increases, the training must become more efficient in order to supply the demand (Croy, 2016). Byrd and Anderson (2012) suggested that training welders efficiently and effectively will be needed in order to manage the predicted deficit of more than 375,000 domestic welders in 2026 projected by Guerra (2018). Welding is a skill that demands extensive practice and training to develop, which is time consuming and costly (Wells & Miller, 2020). Augmented reality (AR) is used to overlay the real-world environments with digital technologies (Yuen et al., 2011). AR is an evolving form of educational training that could be utilized in welding education and skill development. Using simulation technologies, students were able to use AR training to perform specific weld joint configurations (Wells & Miller, 2020). This training technology has the potential to enhance their skill development and their abilities to achieve precise welds (Byrd, 2014; Stone et al., 2011b)

Theoretical Framework

The underlying framework guiding this study was constructed using the skill acquisition theory (DeKeyser, 2015). The development of skills is explained within three stages: 1) declarative, 2) procedural and 3) automatic (DeKeyser, 2015). The declarative stage refers to acquiring knowledge of a skill before attempting to accomplish it. This knowledge is acquired by observation, verbal instruction, a demonstration of the skill or a combination of these allowing for the learners to gain insight in the procedure for the skill. Following the declarative stage, the learner can transition their knowledge of a basic concept into action, known as procedural stage. This stage consists of practice to gain accuracy to successfully accomplish the task. After the procedural stage the learner would gain knowledge to transition into the automaticity stage (DeKeyser, 2015). This stage consists of the learner shifting their behavior to be consistent by rarely showing errors in their work. The knowledge and performance of the skill would need to be refined (DeKeyser, 2015). Engaging students in learning with feedback instead of repetition, will allow them to excel in their skill development (DeKeyser, 2015).

Purpose & Objective

The purpose of this study is to identify the welding professional development needs of students after completing an AR welding training program using Lincoln Electric's REALWELD welding training system. This study aligns with the American Association for Agricultural Education's National Research Agenda Priority Area 5: Efficient and Effective Agricultural Education Programs (Roberts et al., 2016). The purpose of this study is fulfilled by the following objective: To describe the differences in participants' five REALWELD welding parameter scores (work angle, travel angle, CTWD, travel speed, position) in arc-on and arc-off modes.

Methods

During the 2021 spring semester at Texas State University undergraduate students (N = 47) enrolled in an Introduction to Agricultural Engineering course participated in this study.

Utilizing the Lincoln REALWELD training system, each participant completed four arc-off passes and three arc-on passes on a pre-tacked, ¼" mild steel, T joint in the 2F configuration. Researchers overseeing each training protocol created a detailed script for the introduction of the REALWELD training system. After the introduction, researchers gave two demonstrations, using both the arc-off and arc-on modes. Once the demonstrations were complete, each participant conducted four arc-off passes and three arc-on passes, for a total of seven passes per participant per parameter yielding 132 passes recorded for each parameter. Means and standard deviation were conducted to analysis the arc off and arc on scores of the five welding parameters: work angle, travel angle, CTWD, travel speed, and position.

Results

This study collected data from forty-four participants. Mean scores and standard deviations are reported in table 1 for each of the five welding parameter scores. It should be noted there was a statistical significance ($p < 0.05$) between the CTWD and travel speed arc on and arc off scores.

Table 1

Welding Parameter Arc Off and Arc On Scores

Parameter	Arc Off		Arc On	
	M	*SD*	*M*	*SD*
Work Angle	94.32	13.80	90.98	20.84
Travel Angle	91.27	16.97	89.31	16.89
CTWD*	99.11	3.80	90.45	16.95
Travel Speed*	73.30	17.25	78.13	20.80
Position	95.87	11.39	95.26	13.15

Note: Statistically Significant ($p < 0.05$).

Conclusions & Recommendations

We selected the 2F position in order for beginning welders to quickly gain basic welding skills as 2F GMAW welding has been recognized as a less complex joint in novice welders (Stone et al., 2013). Welding scores in the arc-on mode drop after transitioning from the arc-off mode in four of the parameters. This could be related to the increase of anxiety levels going from arc-off to arc-on. Byrd (2014) identified that novice level participants' anxiety levels were triggered during the welding process. Additionally, our findings support Rose et al. (2015) and Stone et al. (2013) as participants were able to weld within the allotted ranges for four of the five parameters over 90% of their welds during both arc-on and arc-off modes.

It was interesting to note that the travel speed improved in the "Arc on" mode, this could be the result of the students being able to see the puddle forming as they are welding. However, we recommend participants continue to focus on improving their travel speed in the arc-off mode before transitioning to the arc-on mode. Participants should consistently score in the 90's for all five parameters in the arc-off mode before advancing to the arc-on mode in order to reduce wasted consumables. We also recommend tightening the tolerance ranges for each of the parameters as student improve their welding skills.

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