Identifying the Relationship Between Augmented Reality Welding Instruction and Welding Performance

Jacob Ramos
Texas State University
601 University Dr.
San Marcos, TX. 78666
512-245-2130
jdr300@txstate.edu

Ryan G. Anderson
Texas State University
601 University Dr.
San Marcos, TX. 78666
512-245-3325
r_a461@txstate.edu

Marshall Swafford
Arkansas Tech University
123C Dean Hall
402 West O St.
Russellville, AR. 72801
479-968-0251
mswafford@atu.edu

Bradley D. Borges
Texas State University
601 University Dr.
San Marcos, TX. 78666
512-245-7106
b_b518@txstate.edu

Identifying the Relationship Between Augmented Reality Welding Instruction and Welding Performance

Introduction

Welding is a manufacturing process that is indispensable to industry and is found in every corner of the world (Stone et al., 2011). With the demand in this industry increasing (Guerra, 2018), welding training needs to be safe, effective, and efficient (Whitney & Stephens, 2014). Previous studies suggest virtual-based welding training can be an effective method to address workforce needs (Abrams et al., 1974; Byrd, 2014; Stone et al., 2011; Wells & Miller, 2020; Whitney & Stevens, 2014). Abrams et al. (1974) suggests complex psychomotor skills can be acquired more efficiently with augmented feedback than performing the skill traditionally. Augmented Reality (AR) is regarded in a broad sense as "augmenting natural feedback to the operator with simulated cues" (Milgram et al., 1994, p. 283). Fields utilizing AR in their research include design, manufacturing, and education (Lee, 2012). Throughout this research, AR welding training is applied by means of audial assistance during mock as well as live welding passes. The Lincoln Electric REALWELD is an AR welding training machine that reinforces welding techniques in an interactive and supervised platform. The Lincoln Electric REALWELD training system has the ability to grade welds while in arc-off (no welding occurring) and arc-on (live welding occurring) modes. Training is achieved by employing audial coaching and welding performance tracking of five key welding parameters including travel speed, contact tip to work distance (CTWD), travel angle, work angle, and position.

Theoretical Framework

The Skill Acquisition theory is the underlying framework of this study. According to the Skill Acquisition theory there are three stages of development an individual progresses through while learning a skill: declarative knowledge, procedural knowledge, and automaticity (DeKeyser, 2015). Declarative knowledge is achieved though research, demonstrations, and observation without acting upon said skill. Participants in our study develop declarative knowledge through classroom lectures and demonstrations. Next, procedural knowledge is achieved when the learner’s understanding of the skill is applied to an experience, such as performing weld passes using a training system. From the procedural stage, learners often experience difficulty progressing to automaticity (DeKeyser, 2015). This is a major hindrance within the traditional method of welding instruction due to the added stress of applying welding as a skill (Byrd, 2014). Audial coaching and arc-off mode in AR training can help advance beginning welders with anxiety through all stages of skill acquisition and ultimately develop the complex skills required of welders.

Purpose & Objectives

The purpose of this study is to determine if a relationship exists between the overall weld scores calculated by the Lincoln Electric REALWELD training system and a certified welding inspector (CWI) scores of beginning welders. 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). Objectives of this study include:

1. Determine if a relationship exists between AR training test scores and CWI scores.
2. Determine if a relationship exists between arc modes and CWI scores.

Methods

During the 2021 spring semester at Texas State University, undergraduate students (*N* = 47) enrolled in the Introduction to Agricultural Engineering course participated in this study. Each participant completed a 2F T joint weld on ¼" mild steel using the Lincoln Electric REALWELD training system. After an introduction and demonstration, each participant conducted four arc-off passes and three arc-on passes. The overall score is calculated by compiling the percent of time a user spends welding within the allotted tolerances. During the final week of the course, students had one laboratory period (1.5 hours) to complete and submit their highest quality weld. The CWI scored each participants' weld in accordance to a sheet covering weld quality developed by Herren (2015). Independent t-tests were conducted to analyze each arc-off and arc-on scores and the reported CWI score.

Results

Table 1 reports the overall mean scores for all participants' weld passes using the REALWELD welding training and the final CWI mean score. The arc-on REALWELD mean weld scores was 56.93 (SD = 27.04). The arc-off REALWELD mean weld scores was 55.98 (SD = 19.12). There was a statistical significance between arc-on and arc-off mean scores with AR training and CWI mean scores (p <0.001).

Table 1

Comparison of REALWELD Mean Scores and Final (CWI) Mean Score (N = 44)

Score	Mean	*SD*	*t*	*p*
Pass 1 (Arc-Off)	55.98	19.12	-7.91	<0.001
Pass 2 (Arc-Off)	63.59	24.67	-4.40	<0.001
Pass 3 (Arc-Off)	70.41	23.49	-2.72	0.009
Pass 4 (Arc-Off)	67.70	24.97	-3.07	0.004
Pass 5 (Arc-On)	56.93	27.05	-5.35	<0.001
Pass 6 (Arc-On)	58.66	29.35	-4.71	<0.001
Pass 7 (Arc-On)	64.39	28.87	-3.60	<0.001
CWI	80.66	11.12		

Conclusions & Recommandations

Our results indicated using AR weld training had a statistically significant impact on CWI scores. Each weld pass had statistically significant impact, regardless of whether it was arc-on or arc-off. We concluded that after each pass with AR training, scores improved. We recommend future studies replicate this study utilizing various weld configurations and processes. Evaluating welding performance on more advanced welding positions and processes will assist in further understanding the effectiveness of the REALWELD in broader aspects of welding education. We also recommend conducting future research that evaluates training durations to determine if additional individualized instruction time improves the overall scores evaluated on the REALWELD.

References

Abrams, M. L., Schow, H. B., & Riedel, J. A. (1974). Acquisition of a psychomotor skill using simulated-task, augmented feedback (evaluation of a welding training simulator). NPRDC-TR-75-13

Byrd, A. P. (2014). Identifying the effects of human factors and training methods on a weld training program. Retrieved from Iowa State University Digital Repository Graduate These and Dissertations. (Paper 13991)

DeKeyser, R. (2015). Skill acquisition theory. In B. VanPatten and J. Williams (Eds.), Theories in second language acquisition: An introduction (2nd ed.) (pp. 94-112). New York, NY: Routledge.

Guerra, E. (2018). National Welding Month: Time to Let Everyone in on the Secret. American Welding Society: Retrieved from: https://www.aws.org/resources/detail/national-welding-month-time-to-let-everyone-in-on-the-secret

Herren, R. (2009). *Agricultural mechanics: fundamentals and applications* (6th ed.). Cengage Learning.

Lee, K. (2012). Augmented reality in education and training. *Techtrends Tech Trends*, *56*, 13-21. https://doi.org/10.1007/s11528-012-0559-3/

Roberts, T. G., Harder, A., & Brashears, M. T. (Eds). (2016). *American Association for Agricultural Education national research agenda: 2016-2020.* Gainesville, FL: Department of Agricultural Education and Communication. 19-28.

Stone, R. T., Watts, K. P., Zhong, P., & Wei, C. (2011). Physical and cognitive effects of virtual reality integrated training. *Human Factors, 53*(5), 558-572. https://doi.org/10.1177/0012720811413389/

Wells, T. and G. Miller. 2020. The effect of virtual reality technology on welding skill performance. *Journal of Agricultural Education, 61.* 152-171.

Whitney, S. & Stephens, A. (2014). Use of simulation to improve the effectiveness of army welding training. *Defence Science and Technology Organisation, AR-016-018.*