Training Beginning Welders Using Virtual Reality Simulations

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Introduction

Incorporating virtual reality (VR) simulation technology into educational environments, specifically agricultural studies, has shown positive effects on skill acquisition (Shoulders & Myers, 2013). VR weld training is beneficial as it allows training to remain safe, cost and time efficient, and educationally effective (Pantelidis, 1993). The Lincoln Electric VRTEX 360 welding simulator aims to improve weld training throughout the industry by decreasing training-associated costs and increasing personalized feedback (*VRTEX® 360® Single User Virtual Reality Welding Training Simulator on Pallet*, 2021). Additionally, instructors using the VRTEX 360 can employ visual parameter cues while users weld in the virtual environment. Cues indicate correct work angle, travel angle, travel speed, position, and contact-tip-to-workpiece distance (CTWD), parameters that are all essential to weld performance. Effects of supplying these cues for beginning welders during training has been studied minimally, thus reinforcing the need for this research.

Byrd et al. (2018) suggested an effective method for training beginning welders includes a mixture of virtual and traditional training. Byrd et al. (2018) saw, after a one-week training period, welders who received 100% VR weld training experienced significant gains in dexterity. Stone et al. (2011) measured cognitive development areas for basic welds and found significantly higher scores for welders who received 50% VR training and 50% traditional training when compared to welders who received 100% traditional training. As virtually integrated weld training provides safe and relevant simulations with constant feedback as welders practice, it allows for faster welding skill development (Wells & Miller, 2020).

Conceptual Framework

The framework of this study, guided by Ausubel's (1962) assimilation theory, is to provide beginner welders with meaningful learning via VR weld process training. The assimilation theory explains that repetitious learning, for example traditional weld training, is less effective than meaningful learning in helping learners develop metacognition and self-regulated learning (Schunk, 2008). Simply, repetitious learning alone is not enough to establish cognitive learning and thus, skill retention; learners must be involved in meaningful learning to understand complex conceptual systems (Ausubel, 1962). In this study VR will provide meaningful learning by employing visual and audial cues, allowing for development of beginning welders' performance skills with sufficient practice time over a four-week span.

Purpose

This study aligns with the American Association for Agricultural Education's (AAAE) National Research Agenda (NRA) Priority Area 4: Meaningful, Engaged Learning in All Environments (Roberts et al., 2016). Providing meaningful, personalized learning to beginning welders will equip them with entry-level welding skills required to enter the welding industry. The purpose of this study is to compare mean scores of beginning welders' virtual and actual welds, using the VRTEX 360 VR simulator and traditional live weld process to complete the welds, respectively.

Methods

This four-week study involved (*n* = 44) undergraduate students enrolled in an Introduction to Agricultural Engineering course at Texas State University. Participants completed a demographic survey and introductory demonstrations to live and VR weld training using the Gas Metal Arc Welding (GMAW) process. After being randomly assigned a weld training sequence, participants performed three single-pass welds in the 2F configuration using the VRTEX 360, then one weld of the same configuration using live welding. Participants completed their virtual welds during either Week One, Two, or Three of the training sequences, depending on assignment. All participants completed live welds during Week Four. Mean scores for welds are calculated by the VRTEX 360 according to the five parameters previously stated. Mean scores for the live welds were assigned by a Certified Welding Inspector (CWI).

Results

Participants' mean scores were 80.11 (*SD* = 9.67) for virtual Weld 1, 82.43 (*SD* = 7.98) for virtual Weld 2, 83.11 (*SD* = 10.22) for virtual Weld 3, and 80.66 (*SD* = 11.12) for the Live Weld. Results displayed in Table 1 show consistently increasing mean scores for welds performed using the VRTEX 360. No statistical significance was found between each of the weld passes and the live weld.

Table 1

Comparison of VRTEX Weld Mean Scores and Live Weld CWI Mean Score (N = 44)

Weld Scored	Mean	*SD*	*t*	*p*
VR Weld 1	80.11	9.67	-0.28	0.78
VR Weld 2	82.43	7.98	0.88	0.39
VR Weld 3	83.11	10.22	1.03	0.31
Live Weld	80.66	11.12		

Conclusion

Participants displayed improved weld scores with each virtual weld performed. Such a pattern reveals that beginning welders likely require additional training time using the VRTEX 360. Presenting mean scores of 80+ following an hour and a half VRTEX 360 weld training session indicates that the participants received meaningful learning as they performed at advanced beginner levels. Presenting a mean score of 80.66 for live welds during the final week of the study indicates participants showed complex weld skill understanding and retention.

As virtual weld scores were comparable to live weld scores, this implies the parameter grading settings within the VRTEX 360 are aligned to the parameter grading used by the CWI. Future research should investigate live and VR weld training utilizing more rigorous parameters within the virtual welding environment to improve overall performance. Recommendations for future practice integrating VR weld training include providing adequate time for learners to familiarize themselves with VR environments and utilizing the personalized feedback cues.

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