**Assessing the influence of welding sequence training on student performance**

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## Introduction

The welding process is prevalent and crucial to agricultural mechanics (Stone et al. 2011a). Additionally, welding requires extensive and costly training to reach proficiency. Traditional welding training is limited in its ability to accurately identify areas of unsatisfactory performance, resulting in inaccurate or insufficient feedback, which ultimately hinders the learner progression towards proficiency. (Abrams et al., 1974). In an attempt to mitigate the limitations existing in traditional training methods, recently, simulator technologies have been integrated into several industries including, medicine, safety training, first responder training, and welding (Wells & Miller, 2020). Virtual Reality (VR) and computer-based audio assisted (CBAA) welding training simulations are designed to serve as educational tools for welding students to reach proficiency more efficiently and effectively.

## Conceptual Framework

The underlying theoretical framework for this study was constructed using both the cognitive information process learning theory (Andre & Phye, 1986) and the skill acquisition theory (DeKeyser, 2015). The cognitive information processing learning (CIP) theory suggests that learning and behavior prevail as a result of the learner's interaction with their environment as well as previously acquired knowledge and experience (Andre & Phye, 1986). As an individual responds to and acts upon their environment, associations begin to develop relating their actions to desired results. The skill acquisition theory describes how individuals progress through the learning process regarding cognitive and psychomotor skills using three stages: 1) declarative, 2) procedural, and 3) automatic (DeKeyser, 2015).

## Purpose and Objectives

The purpose of this study was to determine the most effective sequencing using VR training, CBAA training and traditional welding training when compared to the pass/fail rate of students taking the Certified Welding (CW) test. This study aligns with the American Association for Agricultural Education's National Research Agenda Priority Area 2: New Technologies, Practices and Product Adoption Decisions (Roberts, et al., 2016). The objectives are as follows: (1) Identify the Pass/Fail rate of participants using the sequence of VR, CBAA, and traditional live weld training (2) Identify the Pass/Fail rate of participants using the sequence of CBAA, traditional live weld training and VR (3) Identify the Pass/Fail rate of participants using the sequence of traditional live weld training, VR, and CBAA (4) Determine if there is a difference between the three training sequences, control group, and student performance.

## Methods

Our study was conducted three separate times, across three consecutive semesters in the agricultural mechanics laboratory at Texas State University, however each round of data collection lasted four weeks in duration. Participants consisted of undergraduate students enrolled in an introductory agricultural mechanics course ($n$ = 131). Participants were randomly divided into four distinct welding training groups and received training by rotating through each of the three training environments: VR, CBAA, and the traditional live-weld environment, with the exception of Group 4, that served as out control group who only received traditional training. Training Sequence Group 1 started training in the VR environment, rotated to the CBAA

environment, and concluded with the live-weld training environment, Training Sequence Group 2 started training in the CBAA environment, rotated to the live-weld training environment, and concluded with the VR environment, Training Sequence Group 3 started training in the live-weld training environment, rotated to the VR environment, and concluded with CBAA. During the final week of the study, participants trained exclusively in the live-weld environment, submitting their highest quality weld produced within the lab period to the external CWI (Certified Welding Inspector), for quality analysis. The CWI then determined the pass/fail rates reported below.

## Results

The passing rates of each of the three training sequences are outlined below in Table 1. Training Sequence Group 1 ($n$ = 37) had 16 participants pass the visual examination resulting in a 43.2% passing rate. Training Sequence Group 2 ($n$ = 35) and Training Sequence Group 3 ($n$ = 31) had 13 participants pass the visual examination resulting in a 37.1 % and 41.9% passing rate respectively. Training Group 4 ($n$ = 28) had 11 participants pass resulting in a 39.3% passing rate. The overall passing rate of the four training sequence groups ($N$ = 131) was 40.46% with a total of 53 participants passing the visual examination.

Table 1

*Passing Rates of Each Training Sequence*

| Training Sequence Group | Number of Participants | # of Participants Passing Inspection | Pass Rate % |
|---|---|---|---|
| 1 | 37 | 16 | 43.2 |
| 2 | 35 | 13 | 37.1 |
| 3 | 31 | 13 | 41.9 |
| 4 | 28 | 11 | 39.3 |
| Totals | 131 | 53 | 40.46 |

## Conclusions, Discussions, Recommendations

Although no statistically significant differences were identified between the sequencing of the three training protocols, when used in conjunction, the VR, CBAA, and traditional training protocols resulted in an overall certification rate of 40.46%. Given the amount of practice time allowed to participants, Stone et al. (2011b) achieved a passing rate of ≈ 30% with 100% traditional training methods While Byrd (2014), who used 50% VR training and 50% traditional training to achieve a 66.7% certification rate, differences in participants' previous experience could have led to higher certification rate than that realized by our study. We recommend further research using more difficult welds to master to determine if the welding sequences differentiate between each other and the control group. We recommend that these training methods be implemented based upon the individual needs of each student. If a student is performing well in live-weld training, VR and CBAA could provide benefit by refining area that are unsatisfactory. Conversely, if students are experiencing anxiety regarding the welding process, the VR and CBAA environment could aid in overcoming these obstacles.

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