The integration of virtual reality technology into agricultural education

Kevin Trenton Wells

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The integration of virtual reality technology into agricultural education

by

Kevin Trenton Wells

A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Agricultural Education

Program of Study Committee:
Gregory S. Miller, Major Professor
Scott W. Smalley
Michael S. Retallick
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The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this dissertation. The Graduate College will ensure this dissertation is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University
Ames, Iowa
2019

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DEDICATION

For Margarita, Andrew, and Senyda. May each of your futures be rich with wonder and fulfillment. I love you all very much.
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ABSTRACT

The purpose of this dissertation was to examine virtual reality (VR) technology in the context of agricultural education. This study used both quantitative and qualitative approaches to address three objectives: (1) describe the opinions that school-based agricultural education (SBAE) teachers have about VR technology in the context of SBAE settings, (2) describe the perspectives that students have regarding the use of VR technology in the context of a university-level agricultural mechanics course, and (3) determine the impacts of the use of VR technology on university students’ achievement in the context of welding skill performance.

To address objective one, a census study was conducted during the 2017-2018 academic year with 90 SBAE teachers across Iowa. A questionnaire was distributed to the teachers via Qualtrics. Descriptive statistics were used to analyze the data. The results indicated that the teachers generally held favorable opinions about VR technology intertwined with a considerable degree of uncertainty about the technology and its uses.

To address objective two, a qualitative study was conducted with nine students in a university-level agricultural mechanics course who provided their perspectives on using a VR technology application to develop welding-related psychomotor skills. Two focus groups were convened during the Spring 2018 semester. Qualitative data analysis procedures were used. Three major themes emerged: (1) VR welding and live welding have some degree of alignment, (2) VR technology can have some form of utility as a tool for teaching and learning, and (3) the value of using VR technology often depends on the individual. Student feedback indicated that while using a VR technology application can be useful, it should not take the place of using actual welding equipment as part of the teaching and learning processes.
To address objective three, an experimental study was conducted with 101 undergraduate- and graduate-level students at Iowa State University (ISU). All participants were randomly assigned to undergo one of four training protocols: (1) 100% live welding, (2) 100% VR welding, (3) 50% live welding / 50% VR welding, or (4) 50% VR welding / 50% live welding. Each training protocol was an hour long. A one-way analysis of variance (ANOVA) indicated that there were no statistically significant differences (p > .05) in total weld scores between participants in the four training protocol groups.

The mixed results from this dissertation indicated that while VR technology may have potential for inclusion in agricultural education settings, further examination of the suitability of this technology is needed. Future research should include a focus on the efficacy of VR technology for teaching and learning purposes. Research should also examine the effectiveness of other educational technologies, such as augmented reality (AR) and mixed reality (MR), to determine their potential for impacting the teaching and learning processes. Regarding implications for practice, agricultural education practitioners (e.g., SBAE teachers and university faculty) should consider a myriad of factors before making educational technology adoption decisions, including cost, ease of use, and alignment with course and program objectives.
CHAPTER 1. GENERAL INTRODUCTION

This chapter includes the background and setting, the purpose and objectives, the organizational structure, assumptions and limitations, and definitions of terms.

**Background and Setting**

Issues facing modern society often require impactful and innovative solutions (Roberts, Harder, & Brashears, 2016). In the context of agricultural education, the improved adoption of educational technological applications is helping to create solutions that address present-day needs, particularly those related to teaching and learning (Roberts et al., 2016; Smith, Stair, Blackburn, & Easley, 2018). As flexible and pragmatic educational technologies (e.g., virtual reality [VR] technology, etc.) have evolved over time (Saettler, 2004), agricultural education and its practitioners are in the position to employ advanced educational technologies that can serve a multitude of needs and desires, including factors related to cost, utility, and return on investment. The progressive nature of the agricultural industry, within which agricultural education plays a role, demands that new ideas and technologies be adopted and used to address the challenges of tomorrow (Roberts et al., 2016).

**Statement of the Problem**

The use of various educational technologies can help to create opportunities for educational stakeholders (Smith et al., 2018). VR technology has been observed as a useful instructional component in numerous settings, including: (1) weld process training (Byrd, 2014; Stone, McLaurin, Zhong, & Watts, 2013; Stone, Watts, & Zhong, 2011; Stone, Watts, Zhong, & Wei, 2011), (2) medical science (Cope & Fenton-Lee, 2008; Gallagher et al., 2003; Gor, McCloy, Stone, & Smith, 2003; Kilmon, Brown, Ghosh, & Mikitiuk, 2010; Seymour et al., 2002), (3) science education (Nadolny, Woolfrey, Pierlott, & Kahn, 2013), (4) first responder
training (Bliss, Tidwell, & Guest, 1997), and (5) mine safety training (Filigenzi, Orr, & Ruff, 2000). As such, this approach to teaching and learning exhibits much potential to improve learning outcomes (Byrd, 2014; Stone et al., 2013).

As challenges continuously arise in the agricultural industry and in the world more broadly, agricultural education practitioners should be prepared to adopt and subsequently use new innovations, practices, concepts, and ideas to address such issues as stakeholder engagement and formal and non-formal instruction (Lindner, Rodriguez, Strong, Jones, & Layfield, 2016). Perhaps VR technology could serve as a useful method for addressing issues found in agricultural education. Effective teaching and learning processes involve the use of different approaches to appropriately address learners’ needs (Phipps, Osborne, Dyer, & Ball, 2008). To date, little research has been conducted about the use of VR technology within the context of agricultural education. As VR technology can provide tangible benefits for educational stakeholders (Byrd et al., 2015; Nadolny et al., 2013), an examination of its utility in and suitability for agricultural education settings is warranted.

**Purpose and Objectives of the Study**

The purpose of this dissertation was to examine VR technology in the context of agricultural education. As such, the specific objectives of the dissertation study included:

1) Describe the opinions that school-based agricultural education (SBAE) teachers have about VR technology in the context of SBAE settings.

2) Describe the perspectives that students have regarding the use of VR technology in the context of a university-level agricultural mechanics course.

3) Determine the impacts of the use of VR technology on university students’ achievement in the context of welding skill performance.
Dissertation Organization

This dissertation is divided into six chapters. Chapter One provides a general introduction to the study. Chapter Two provides a broad literature review related to educational technology usage in the context of agricultural education settings. Chapter Three is a research article that describes the results of a descriptive study regarding teachers’ opinions about VR technology in the context of SBAE settings. Chapter Four is a research article that describes the results of a qualitative study addressing students’ perspectives on using VR technology in the context of a university-level agricultural mechanics course. Chapter Five is a research article that reports the impacts of the use of VR technology on university students’ achievement in the context of welding skill performance. Chapter six includes general discussion, conclusions, and recommendations about the entire study.

Assumption

It was assumed that the use of random assignment to the groups used within the experimental study would allow for the control of factors that could have influenced the results of the study. These factors include the possibility that some students may have had prior experience with using welding equipment and that some students may have previously used the VR technology (i.e., the Lincoln Electric VRTEX® 360 VR welding system) employed within the study. This assumption applies to Chapter Five only.

Limitations

This study included SBAE teachers throughout the state of Iowa. These teachers had broad ranges of knowledge and experience levels related to VR technology applications and usage. It should be emphasized that this sample of teachers is not representative of all SBAE teachers across the United States. This limitation applies to Chapter Three only.
This study included students enrolled in the Agricultural Mechanics Applications (AgEdS 388) course at Iowa State University (ISU) during the Spring 2018, Summer 2018, and Fall 2018 semesters. It should be emphasized that this sample of students is not representative of all students enrolled at ISU. This limitation applies to Chapters Four and Five.

This study included a wide variety of undergraduate and graduate students enrolled at ISU. These students had varying skill, experience, and knowledge levels related to welding and VR technology applications and usage. It should be emphasized that this sample of students is not representative of all university students across ISU or the United States. This limitation applies to Chapter Five only.

Definition of Terms

The key terms utilized within the study are listed below along with their definitions.

1) **2F**: “a fillet weld made in the horizontal position” (Bowditch, Bowditch, & Bowditch, 2017, p. 603).

2) **Certified welding inspector (CWI)**: an individual who, in accordance with American Welding Society (AWS) standards, is certified to successfully “determine if a weldment meets the acceptable criteria of a specific code, standard, or other document” (American Welding Society, 2007, p. vii).

3) **Fillet weld**: “an inside corner weld made at the intersection of two surfaces that form a right (90°) angle” (Bowditch et al., 2017, p. 600).

4) **Gas metal arc welding (GMAW)**: “an arc welding process that uses a continuously fed consumable electrode and a shielding gas” (Bowditch et al., 2017, p. 602).

5) **Horizontal welding position**: “a welding position in which the weld axis is nearly horizontal and the surface is nearly vertical” (Bowditch et al., 2017, p. 603).
6) **Educational technology**: “the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources” (Januszewski & Molenda, 2008, p. 1).

7) **Personal protective equipment**: “the eye, ear, head, hand, arm, leg, foot, and general body protective equipment used by each individual on the job” (Bowditch et al., 2017, p. 609).

8) **Psychomotor skills**: the application of physical processes in connection with mental activities (Lancelot, 1944; Venes, 2017).

9) **Shielding gas**: “a gas, usually inert, that is used to blanket the welding area and prevent contamination from the air” (Bowditch et al., 2017, p. 613).

10) **Virtual reality (VR)**: “a three-dimensional, computer-generated environment which can be explored and interacted with by a person” (Virtual Reality Society, 2017, ¶ 5).

11) **VRTEX® 360**: A virtual reality weld training system that, through the use of instantaneous feedback, actual welding parameters, and realistic-appearing environments, can be used as a method of training for novice and experienced welders (Lincoln Electric, 2017).

12) **Weld**: “the blending or mixing of two or more metals or nonmetals by heating them until they are molten and flow together” (Bowditch et al., 2017, p. 617).

13) **Welding**: “a joining process that produces coalescence of materials by heating them to the welding temperature” (Bowditch et al., 2017, p. 617).

14) **Weldment**: “an assembly of parts joined by welding” (Bowditch et al., 2017, p. 618).

**References**


CHAPTER 2. LITERATURE REVIEW

Introduction and Conceptual Framework

A need exists for solutions to issues facing the agricultural industry (Roberts, Harder, & Brashears, 2016). In recent years, demands for change have resulted in the need to adopt new practices, concepts, ideas, and strategies to ensure that agricultural education as a discipline is poised to address current and future issues (Lindner, Rodriguez, Strong, Jones, & Layfield, 2016). As agricultural education has in recent years become broader in scope and nature, it is imperative that its practitioners consider pursuing new avenues, such as using emerging technologies, to help address the issues faced in today’s world (Doerfert, 2011).

Agricultural education, broadly defined, can allow for idea dissemination, topic exploration, and engagement in the agricultural industry (Roberts et al., 2016). School-based agricultural education (SBAE) can serve as both a context and content area for teaching and learning (Roberts & Ball, 2009). Roberts and Ball’s (2009) Conceptual Model for Agricultural Subject Matter as a Content and Context for Teaching (see Figure 1) guided this research.

The selection criteria for this model was multi-faceted. According to Roberts and Ball (2009), “agriculture provides a rich context in which learning can occur” (p. 87), thus recognizing that agricultural education is broad and encompasses many areas, including emerging technologies. The individual components of the model provide guidance for this study as well. Knowledge across Domains could include how both teaching and learning processes can occur in both physical and virtual worlds provided in an educational setting. Industry-Validated Agricultural Curricula refers to the content taught in agricultural education that should be rooted in actual agricultural industry practices and concepts. Integrated Curricula would, in the context of this dissertation study, refer to the infusion of technology-focused topics included within the curricula.

Learners would be classified as those individuals who engage in the learning process in the agricultural education setting while Educators would refer to those entities that provide for the teaching and learning experience. Interestingly, Educators could mean more than just human teachers; rather, as described later in this chapter, technology itself could serve as an educational source, especially when considering Vygotsky’s (1978) zone of proximal development (ZPD). The Facilitation of Learning component of this model, which is the primary element focused upon by this study, refers to how the teaching and learning processes occur. The focus of this study contextualizes Facilitation of Learning through using virtual reality (VR) technology in both the teaching and learning processes. The tangible results of this model depict a Skilled Agricultural Workforce in conjunction with Successful Lifelong Learners that are Agriculturally Literate Citizens, which is a reasonable expectation of the agricultural education system. This model is, much like the use of educational technology (Duffy & Jonassen, 1992), supported by constructivist learning theory (Roberts & Ball, 2009).
Agricultural education is dynamic and flexible, and such traits are valuable in addressing future needs and wants (Roberts et al., 2016). Considering its development over time and its increasing inclusion in other educational contexts (Youngblut, 1998), VR technology holds much potential for inclusion into the teaching and learning processes in agricultural education settings. The remainder of this chapter will explore additional literature that addresses various aspects of the scope of this dissertation study, including technology applications in the context of agricultural education, simulator technologies, VR technology, psychomotor skill development, and constructivist learning theory, all of which are contextualized in the realm of educational technology.

**Educational Technology Applications in the Context of Agricultural Education**

The agricultural industry exists in a state of constant, dynamic, and exciting change (Doerfert, 2011; Roberts et al., 2016). As such, agricultural education practitioners, broadly defined, should be prepared to address the needs for change via new methods and technologies (Roberts et al., 2016; Lindner et al., 2016). Agricultural education as a discipline is well-poised to answer present and future challenges that face the agricultural industry, particularly through the adoption of new technologies (Lindner et al., 2016).

Historically, computer applications and integration have received substantial attention in the agricultural education literature, particularly in SBAE settings. Numerous scholars have examined different facets of computer technology, including: (1) SBAE teachers’ professional development and competency needs (Miller & Foster, 1985), (2) computer-assisted instruction for SBAE teachers (Trede, Russell, & Miller, 1985), (3) SBAE teachers’ computer usage anxiety (Fletcher & Deeds, 1994; Kotrlik & Smith, 1989), (4) undergraduate students’ computer-related experiences, self-efficacy, and knowledge (Johnson, Ferguson, & Lester, 1999; Johnson &

Beyond computers, agricultural education practitioners have implemented efforts related to a range of technologies for teaching and learning purposes: (1) digital games (Bunch, Robinson, Edwards, & Antonenko, 2014; Bunch, Webb, & Robinson, 2015), (2) simulator technologies (Agnew & Shinn, 1990; Perritt, 1984), (3) smartphones (Smith, Stair, Blackburn, & Easley, 2018), iPods (Murphrey, Miller, & Roberts, 2009), (4) interactive whiteboards (Bunch, Robinson, & Edwards, 2015), (5) social media (Settle, Telg, Baker, Irani, Rhoades, & Rutherford, 2012), (6) social networking (Murphrey, Rutherford, Doerfert, Edgar, & Edgar, 2012), (7) web-based courses (Alston & English, 2007), (8) information technology (Anderson & Williams, 2012; Kotrlik, Redmann, & Douglas, 2003; Kotrlik, Redmann, Harrison, & Handley, 2000), and (9) educational technology more broadly (Alston, Miller, & Williams, 2003; Birkenholtz & Stewart, 1991; Coley, Warner, Stair, Flowers, & Croom, 2015; Kotrlik & Redmann, 2009; Williams, Warner, Flowers, & Croom, 2014a, 2014b) have all received attention in the context of agricultural education settings. Thus, more recent years have yielded a
greater diversity of technological applications in agricultural education. Several of these authors (Bunch et al., 2014; Bunch et al., 2015; Smith et al., 2018) have found that educational technologies can be beneficial to the teaching and learning processes in agricultural education.

The use of the technological applications has been positively received within agricultural education. Murphrey et al. (2012) noted that “[t]echnology has the potential to improve education but only if it is applied with purpose and consideration of the audience” (p. 56). What is more, the use of technology is well-supported in the realm of education more broadly, as indicated by the United States Office of Educational Technology (n.d.):

Technology can be a powerful tool for transforming learning. It can help affirm and advance relationships between educators and students, reinvent our approaches to learning and collaboration, shrink long-standing equity and accessibility gaps, and adapt learning experiences to meet the needs of all learners. (¶ 2)

Educational technologies come in many forms to serve many purposes (Saettler, 2004). The use of technology-based platforms appears to positively impact teaching and learning, as evidenced by prior research (Agnew & Shinn, 1990; Bunch et al., 2014). As technology continues to change at a rapid pace, agricultural education must adapt and continue to make accommodations that support the teaching and learning processes (Alston & English, 2007; Kotrlik et al., 2003; Roberts et al., 2016).

In the context of SBAE, teachers often use “the technologies that are easy to access” (Williams et al., 2014a, p. 202), thus indicating that the adoption of newer technologies that may not have previously been easy to access may be an issue to overcome. Access to new technologies can be problematic at times (Kotrlik & Redmann, 2009). Colby et al. (2015) noted that many educational technologies are not regularly available to agricultural education
stakeholders. A lack of regular access to high-quality educational technologies can serve to hinder the teaching and learning processes in agricultural education settings (Kotrlik & Redmann, 2009; Kotrlik et al., 2003).

Perhaps part of the educational technology availability issue is self-inflicted. Smith et al. (2018) concluded that agricultural education practitioners are often hesitant to adopt new educational technologies and typically opt to prolong the technology adoption process. Thus, it stands to reason that perhaps agricultural education stakeholders may be reasonably content with the educational technologies presently available to them and may choose to lag behind.

When considering these concepts, it is important to recognize that agricultural education practitioners do encounter both successes and shortcomings regarding technology-based applications. Per Kotrlik et al. (2003), many practitioners experience anxiety when considering the application of technology into their instructional designs. In addition, several barriers to effective technology integration do exist, such as expense, cost, availability, interest levels, and more (Alston et al., 2003; Coley et al., 2015; Williams et al., 2014b).

Practitioners tend to have positive attitudes toward educational technology usage (Williams et al., 2014b). Bunch et al. (2015) noted that SBAE teachers “perceived [interactive whiteboards] IWBs assisted them in increasing technology use in their classrooms, and they planned to continue using IWBs” (p. 72). Moreover, Alston and English (2007) indicated that the use of technology has been well-received by students, particularly from the standpoint of pragmatism and utility. While some issues do exist and may always be present, positive experiences can be had by various agricultural education stakeholders.

Regarding virtual simulations, Alston et al. (2003) indicated that teachers appeared to have mixed perceptions about the roles that these technologies would play in the future of SBAE.
To that end, Williams et al. (2014a) noted that some teachers use simulations as part of the planning and instructional processes at least several times per year while others lack access to or never use such tools. Perhaps existing educational technology adoption barriers, such as cost or a lack of knowledge about their applications for teaching and learning purposes, have kept these potentially valuable types of educational technology away from agricultural education practitioners. Phipps, Osborne, Dyer, and Ball (2008) reported that educational technologies occupy an important role in many agricultural education settings.

**Simulator Technologies in the Context of Educational Technology**

Thiagarajan (1998) described simulation as “a representation of the features and behaviors of one system through the use of another” (p. 35). To date, simulator technologies have been used and studied in many contexts for several different purposes. These contexts have included: (1) mine safety training (Filigenzi, Orr, & Ruff, 2000), (2) weld process training (Abrams, Schow, & Riedel, 1974; Byrd, 2014; Byrd, Stone, Anderson, & Woltjer, 2015; Oz, Ayar, Serttas, Iyibilgin, Soy, & Cit, 2012; Stone, McLaurin, Zhong, & Watts, 2013; Stone, Watts, & Zhong, 2011; Stone, Watts, Zhong, & Wei, 2011; White, Prachyabrued, Chambers, Borst, & Reinders, 2011), (3) first responder training (Bliss, Tidwell, & Guest, 1997), (4) medical science (Cope & Fenton-Lee, 2008; Gallagher et al., 2003; Gor, McCloy, Stone, & Smith, 2003; Kilmon, Brown, Ghosh, & Mikitiuk, 2010; Kneebone, 2005; Seymour et al., 2002), (5) agricultural education (Agnew & Shinn, 1990; Perritt, 1984), and (6) science education (Nadolny, Woolfrey, Pierlott, & Kahn, 2013). As simulator technologies have done in the past, it is expected that they will continue to evolve in scope and quantity (Thiagarajan, 1998). Concomitantly, their beneficence and efficacy are expected to be quite high in the coming years (Kneebone, 2005).
Using simulator technologies for teaching and learning purposes has the potential to result in positive impacts on learner development (Abrams et al., 1974; Nikolic, Radivojevic, Djordjevic, & Milutinovic, 2009; Scalese, Obeso, & Issenberg, 2008). Simulator technologies can help to reduce anxiety when learning a new skill domain (Byrd, 2014) and can assist in alleviating potential risks that may be present when performing a live-exercise task (Seymour et al., 2002). Interestingly, new and emerging technologies such as VR (Youngblut, 1998) and augmented reality (AR) (Lee, 2012; Yuen, Yaoyuneyong, & Johnson, 2011) can be used to increase the diversity of simulator technologies in terms of form and function (Scalese et al., 2008). Wenglinksy (1998) cautioned that technology usage alone does not necessarily facilitate positive change. Instead, he advised that the selection of an educational technology, such as a VR technology, should be appropriate and pragmatic for the teaching and learning situation.

**Virtual Reality Technology in the Context of Educational Technology**

Using VR technology for educational purposes has been identified as practical and viable (Youngblut, 1998). VR is defined by the Virtual Reality Society (2017) as “a three-dimensional, computer-generated environment which can be explored and interacted with by a person” (¶ 5). VR technology has advanced a great deal since its debut (Brooks, 1999). In the early 1990s, Pantelidis (1993) propositioned that VR technology would serve a much greater capacity for teaching and learning in the future years. Helsel (1992) stated that “[v]irtual reality holds much promise for education… education has a tremendous wealth of information and experience to bring to the VR curriculum” (p. 42). VR technology has been extensively studied in a diversity of contexts, including medicine (Gor et al., 2003; Kilmon et al., 2010), weld process training (Stone et al., 2013), and education (Nadolny et al., 2013). These studies have shown that VR technology can be flexible and beneficial when appropriately adopted and used.
Jarmon, Traphagan, Mayrath, and Trivedi (2009) noted that the application of VR technology in educational settings can be beneficial to student learning and achievement. Further, the use of VR technology can help to provide the ability to implement useful hands-on activities that can benefit the teaching and learning processes in several ways, especially when considering that students can make mistakes without actual physical repercussions, perform experimentation with techniques and procedures, and over the course of time develop a greater level of expertise with a skill area, topic, or concept (Häfner, Häfner, & Ovtcharova, 2013). As VR technology can help to develop dexterity and expertise (Byrd, 2014; Seymour et al., 2002), its potential utility for inclusion into the educational process is worth noting (Kneebone, 2005).

Professional settings incorporate VR technology into the curriculum to help supplement the educational experiences received (Verdaasdonk, Stassen, van Wijk, & Dankelman, 2007). However, following the suggestions of Wenglinsky (1998), the use of an educational technology should be used to aid in the teaching process, not replace it entirely. Kneebone (2005) noted that challenges exist regarding using simulator technologies, which can include VR technology, and outlined four key points illustrating how they can be evaluated for use in the educational process:

Simulations should allow for sustained, deliberate practice within a safe environment, ensuring that recently acquired skills are consolidated within a defined curriculum which assures regular reinforcement. Simulations should provide access to expert tutors when appropriate, ensuring that such support fades when it is no longer needed. Simulations should map onto real-life clinical experience, ensuring that learning supports the experience gained within communities of actual practice. Simulation-based learning environments should provide a supportive, motivational, and learner-centered milieu that is conducive to learning. (p. 552)
Stone et al. (2013) noted that solely relying on VR technology for teaching and learning purposes may not be as beneficial as an integrated approach that supplements live experience with VR technology. Moreover, Stone et al. (2013) indicated that the use of overlay systems with VR technology equipped to do so may, when used in excess, do more harm than good, particularly as attention is diverted from the task at hand. In essence, VR technology has great potential to enhance the teaching and learning processes (Youngblut, 1998); however, educational technologies have a distinct role in these processes, particularly when considering just how much such things should be used in educational settings (Wenglinsky, 1998).

**Psychomotor Skill Development in the Context of Educational Technology**

As one of the primary purposes behind the use of simulator technologies in educational settings, the learning of psychomotor skills has been an important consideration (Kneebone, 2005). Psychomotor skills can be characterized as a linkage between the cognitive and physical processes that require physical motions and mental stimulation to successfully accomplish the task at hand (Venes, 2017). Examples of psychomotor skills include skiing, dancing (Wulf, 2007), surgery (Kaufman, Wiegand, & Tunick, 1987), and welding (Bowditch, Bowditch, & Bowditch, 2017; Byrd, 2014). Human-related factors (e.g., comfort, prior performance-related experience, dexterity, anxiety, etc.) can affect psychomotor performance in a given setting (Byrd, 2014). Osborne (1986) noted that the psychomotor skill development process can be lengthy and complex yet rewarding. Moreover, Osborne (1986) suggested that a variety of instructional methods and behaviors could be useful and practical for refining the psychomotor skill development process.

Wulf (2007) determined that developing psychomotor skills for use in a given context can consist of a considerable amount of time, effort, feedback, and continuous practice.
Furthermore, the use of effective strategies to enhance the acquisition of abilities in a subject area is vital for success in the teaching and learning of skills within that subject matter (Goldsmith, Stewart, & Ferguson, 2006). As Ohlsson (1996) noted, errors are a part of the learning process. Ideally, through repetitive practice, feedback, correction, and reapplication, individuals can minimize their mistakes over time (Ohlsson, 1996). Applying these notions to the context of agricultural education settings, Phipps et al. (2008) expressed that simulator technologies are an example of instructional aids and that psychomotor skill development is often an objective of the teaching and learning processes. Perhaps the idea of using technological applications that can be used for psychomotor skill development could have merit as part of teaching and learning in agricultural education contexts.

Constructivist Learning Theory in the Context of Educational Technology

Technology usage within educational settings is supported by educational philosophy and theory (Duffy & Jonassen, 1992; Saettler, 2004). This is particularly true regarding constructivist learning theory (Saettler, 2004). Constructivism emphasizes that an individual frames his or her understanding of a learning event based on prior knowledge or experiences.

Piaget (1972) described how new information can be processed and compartmentalized for later use (i.e., schemes). Moreover, John Dewey (1916) opined that education is progressive in its nature and noted that the development of mental faculties can be facilitated through a diversity of connections and interactions between concepts and mediums. In 1938, Dewey noted that experience with a subject is fundamental to the educational system and process.

Considered an important thinker in constructivist learning theory, Vygotsky (1978) wrote that the use of tools could positively impact intellectual development over time. Moreover, Vygotsky’s (1978) concept of the zone of proximal development (ZPD) further supports the
alignment between educational technology and constructivist learning theory. As a concept, ZPD is supported by the idea that the knowledgeable or knowledge-giving can be partnered with an individual who lacks knowledge, or is knowledge-receiving, producing a resulting practical transfer of knowledge and skills that helps to benefit all involved parties.

The instructor of a university-level agricultural mechanics course may take several different approaches to assist an inexperienced student who is attempting to learn how to perform a 1G position butt joint weld using the gas metal arc welding (GMAW) process. One possible option would be to pair this inexperienced student with a knowledgeable, skilled, experienced student who has demonstrated considerable proficiency with this particular weld. Per Vygotsky (1978), this pairing could grant both students the opportunity to teach and learn from each other, creating a mutually beneficial relationship. Another option could be to take the same inexperienced student and provide him or her the opportunity to use the Lincoln Electric VRTEX® 360 VR welding system, which is a VR simulator technology produced by welding equipment manufacturer Lincoln Electric to help provide opportunities to teach and learn welding (Lincoln Electric, 2017) to improve his or her welding-related psychomotor skills. Through using the Lincoln Electric VRTEX® 360 VR welding system, the student could alter his or her welding skill performance, continuously practice the designated weld, and receive corrective feedback to help, thereby allowing the use of a piece of educational technology to serve as a facilitator of skill development in the ZPD. Additionally, this example fulfills Vygotsky’s (1978) notion that tool usage can promote intellectual development.

**Summary**

Agricultural education is a complex discipline that involves many facets (Roberts et al., 2016). As part of this structure, a priority of the agricultural education system is to continuously
implement new educational technologies that serve stakeholders positively (Lindner et al., 2016). Educational technology is supported by constructivist learning theory (Duffy & Jonassen, 1992) and has a considerable history of usage in agricultural education settings. As an example of educational technology, simulator technologies, particularly VR technology, hold much potential for assisting the facilitation of the teaching and learning processes (Thiagarajan, 1998). VR technology can serve a multitude of functions, including contextualized, transferable psychomotor skill development (Byrd, 2014) and academic content education (Nadolny et al., 2013).

References


CHAPTER 3. TEACHERS’ OPINIONS ABOUT VIRTUAL REALITY TECHNOLOGY IN SCHOOL-BASED AGRICULTURAL EDUCATION

A paper prepared for submission to the *Journal of Agricultural Education*

Trent Wells and Greg Miller

Abstract

Technology in school settings has undergone a tremendous degree of evolution in recent decades (Saettler, 2004). Educational technologies can be used for a wide range of applications. In school-based agricultural education (SBAE) settings, an assortment of educational technologies is often used to achieve instructional objectives (Phipps, Osborne, Dyer, & Ball, 2008). As a computer-based technology, virtual reality (VR) technology has been applied in educational contexts for years and is anticipated to grow in use and popularity (Bailenson, 2018). VR technology has received little attention in SBAE-focused research. Through the lens of an adapted version of Fishbein and Ajzen’s (2010) reasoned action model, we sought to describe the opinions that teachers have regarding VR technology in SBAE. Following Dillman, Smyth, and Christian’s (2014) recommendations, we used an Internet-based questionnaire to collect data from 90 SBAE teachers in Iowa during the 2017-2018 academic year. Our results indicated that the teachers generally held favorable opinions about VR technology intertwined with a considerable degree of uncertainty about the technology and its uses. To facilitate opportunities for VR technology-related professional development, we recommend that agricultural teacher education faculty develop their own knowledge and skills related to VR technology applications.

Introduction

Technology has long been a landmark contributor to the American school experience (Saettler, 2004). From the use of books, pencils, and paper to the incorporation of advanced computer hardware, software, and films, technology has become engrained in American
classrooms and is consistently re-defined and expanded (Saettler, 2004). Regarding the impacts of technology in educational environments, the United States Office of Educational Technology (n.d.) stated that:

Technology can be a powerful tool for transforming learning. It can help affirm and advance relationships between educators and students, reinvent our approaches to learning and collaboration, shrink long-standing equity and accessibility gaps, and adapt learning experiences to meet the needs of all learners. (¶ 2)

The use of technology as an assistive tool is supported by educational philosophers, psychologists, and theorists (Saettler, 2004). Education is progressive in nature and mental faculties can be developed through connections and interactions between concepts and mediums (Dewey, 1916). This could include those connections offered between technologies and their use in an educational environment. Vygotsky (1978) noted that using tools can positively contribute to intellectual development over time.

Educational technology has continued to evolve and broaden within a multitude of common everyday settings (Saettler, 2004). Examples of technologies that have emerged more prominently over the past three decades include: (1) mobile devices (Park, 2011), (2) digital games (Amory, Naicker, Vincent, & Adams, 1999), (3) web-based resources (Gray, Thomas, Lewis, & Tice, 2010), (4) augmented reality (AR) (Lee, 2012; Yuen, Yaoyuneyong, & Johnson, 2011), (5) mixed reality (MR) (Hughes, Stapleton, Hughes, & Smith, 2005), and (6) virtual reality (VR) (Youngblut, 1998). In recent years, these technologies have become more readily available to classroom teachers (Gray et al., 2010). The rise of such technologies has helped to increase the dissemination of advanced modern technologies into American classrooms (Gray et al., 2010).
The impact of educational technology use on the teaching and learning processes can vary. For example, Stone, Watts, and Zhong (2011) found that the use of VR technology can be positively impactful on skill development processes. However, Wenglinsky (1998) cautioned “that technology could matter, but that this depended on how it was used” (p. 1). Wenglinsky (1998) further admonished that quantity of availability and use of educational technology does not necessarily equate to improved educational impact; rather, practitioners should carefully consider how a type of educational technology is employed in order to maximize the learning potential.

Phipps, Osborne, Dyer, and Ball (2008) acknowledged that educational technologies can be powerful tools for teaching and learning in school-based agricultural education (SBAE) settings. Mimicking the nature of educational technology in education more broadly, educational technologies used in SBAE have evolved considerably. Educational technologies that have been studied within the SBAE-focused research include: (1) smartphones (Smith, Stair, Blackburn, & Easley, 2018), (2) interactive whiteboards (Bunch, Robinson, & Edwards, 2015), (3) serious digital games (Bunch, Robinson, Edwards, & Antonenko, 2014, 2016), (4) iPods and MP3 players (Murphrey, Miller, & Roberts, 2009), (5) physical simulation systems (Agnew & Shinn, 1990; Perritt, 1984), and (6) computers (Miller & Kotrlik, 1987; Smith et al., 2018).

SBAE teachers recognize the value in integrating educational technologies into their curricula (Williams, Warner, Flowers, & Croom, 2014b). SBAE teachers have indicated that their local school districts and administrators are supportive of infusing educational technologies into SBAE programs (Smith et al., 2018; Williams et al., 2014b). Williams, Warner, Flowers, and Croom (2014a) found that North Carolina teachers often have access to or use some educational technologies but not always others.
Barriers such as cost may inhibit educational technology adoption and use (Alston, Miller, & Williams, 2003; Coley, Warner, Stair, Flowers, & Croom, 2015; Williams et al., 2014b), which may result in missed opportunities for progress and change. Kotrlik, Redmann, and Douglas (2003) cautioned “that much more needs to be done to encourage and support [SBAE] teachers in the teaching/learning process” (p. 88). As such, progress is a prerequisite for useful change. Kotrlik et al. (2003) advised that effective change regarding educational technology integration and education can be implemented by SBAE stakeholders. Anderson and Williams (2012) noted that a considerable number of SBAE teachers have taught themselves how to use the technologies available to them. As such, teachers may be willing to learn how to use available technologies if benefits are expected.

VR technology can be described as “a three-dimensional, computer-generated environment which can be explored and interacted with by a person” (Virtual Reality Society, 2017, ¶ 5). VR technology can be used for a variety of functions, including skill-oriented training, social entertainment, and educational purposes (Bailenson, 2018). The use of VR technology in the context of educational environments dates back several decades. Helsel (1992) wrote positively of VR technology’s potential for use in education, noting that “[v]irtual reality holds much promise for education… [just as] education has a tremendous wealth of information and experience to bring to the VR curriculum” (p. 42). Pantelidis (1993) suggested that as of the early 1990s, VR technology could have much potential to help address educational needs in the coming years. More recently, Potkonjak et al. (2016) described that greater access to resources and more flexible teaching and learning opportunities offered via some forms of VR technology could help to improve the teaching and learning processes.
As a developmental tool, VR technology has found useful roles in the teaching, learning, and assessment practices in various career areas. In weld process training, VR technology has been used as a skill development method in several studies (Byrd, 2014; Byrd, Stone, Anderson, & Woltjer, 2015; Stone et al., 2011; Stone, McLaurin, Zhong, & Watts, 2013). Cope and Fenton-Lee (2008) examined the use of a VR technology as an assessment tool in surgical training, while Filigenzi, Orr, and Ruff (2000) applied VR technology to mine safety training. Within each of these contexts, VR technology found its place as a method to help provide initial exposure to subject matter and to positively reinforce skill development.

Alston et al. (2003) found that SBAE teachers expressed mixed perceptions about VR technology in SBAE. In recent years, VR technology has changed considerably and has become more widely accepted and used in educational settings (Bailenson, 2018; Potkonjak et al., 2016). What are SBAE teachers’ opinions about using VR technology over a decade later?

**Theoretical Framework**

We adapted Fishbein and Ajzen’s (2010) reasoned action model (see Figure 1) to serve as the theoretical framework that guided our study. This model served as a guide to better understand how SBAE teachers’ opinions about VR technology may ultimately impact their intentions and behaviors regarding VR technology.
Within this adapted model, Fishbein and Ajzen (2010) surmised that a variety of factors ultimately influence human behavior, noting that “[a]s a general rule, the more favorable the attitude and perceived norm, and the greater the perceived behavioral control, the stronger should be the person’s intention to perform the behavior in question” (p. 21). Fishbein and Ajzen (2010) postulated that individuals’ backgrounds (e.g., personal and professional values, prior experiences, knowledge about a subject, etc.) are a foundational root of behavioral intention that influence behavioral, normative, and control beliefs. Behavioral beliefs influence attitudes toward a behavior, normative beliefs impact perceptions about the norm, and control beliefs affect perceived behavioral control, which influence intentions that, along with interventions via actual control that emerges from one’s own skills, abilities, and environmental factors, impact a behavior or set of behaviors.

In the context of our study, we operationalized behavior as the use of VR technology in SBAE settings for teaching and learning purposes. We believed that personal, individualized
factors such as opinions about VR technology, previous experiences with using or even observing VR technology, educational level, and professional experiences and values could ultimately guide SBAE teachers’ behaviors regarding VR technology adoption and use. Perceptions and realities about other teachers’ use of VR technology can impact intentions to pursue the use of VR technology in SBAE settings. Teachers’ beliefs about and attitudes toward the use of VR technology in their own SBAE programs can influence intentions and behaviors. Opinions and actualities about control and perceived control regarding the learning environment are also influential variables. Teachers’ own skills, abilities, and environmental factors such as available space, funding, curricula being taught, students’ needs, and school administrators’ support were categorized as actual controls that can impact perceived behavioral control and impact behaviors.

As documented by Anderson and Williams (2012), SBAE teachers often view the use of different types of technologies for education-related purposes favorably. Perhaps the same is true regarding VR technology in SBAE programs. Because initial opinions and beliefs can impact individuals’ adoption- and use-related behaviors (Fishbein & Ajzen, 2010), understanding SBAE teachers’ opinions about VR technology can help the profession to better understand the utility of this educational technology within SBAE programs.

**Purpose and Objectives of the Study**

The purpose of our study was to describe the opinions that teachers have about VR technology in SBAE settings. To address this purpose, we established the following objectives to guide this study:

1) Describe teachers’ self-reported experiences with VR technology.

2) Describe teachers’ opinions regarding VR technology.
3) Describe teachers’ perceived frequency of incorporating new and emerging instructional technologies.

The present study aligned with the American Association for Agricultural Education (AAAE) National Research Agenda (NRA) Research Priority Area 2: New Technologies, Practices, and Products Adoption Decisions (Lindner, Rodriguez, Strong, Jones, & Layfield, 2016). Understanding SBAE teachers’ opinions about VR technology can help agricultural education stakeholders, such as teacher educators and software and hardware developers and programmers, to better understand how to identify, plan, design, and implement VR technology that may be beneficial to SBAE programs and curricula.

**Methods**

This descriptive study sought to examine teachers’ opinions about VR technology in SBAE. To accomplish this purpose, we developed and used an electronic questionnaire. Based on the recommendations of Ary, Jacobs, and Sorensen (2010), a panel of experts was used to determine the face validity, construct validity, and content validity of the questionnaire. Three panel members were selected based upon their backgrounds as former SBAE teachers and current agricultural teacher educators. Their past professional experiences included working with simulator technologies. Two panel members taught at land-grant, research-focused universities while the third taught at a regional, teaching-focused university.

We sent detailed instructions to the panel members. We sent each panel member a copy of the questionnaire as well as guidelines for the review process. We asked the panel members to evaluate only the items that addressed teachers’ opinions about VR technology. The items not evaluated by the panel members included nine items regarding teachers’ use of VR technology, six items that addressed teacher demographics, and five items concerning SBAE program and
school demographics. We did not ask the panel members to evaluate these specific items because they were designed only to provide greater details about the teachers’ backgrounds with VR technology. We addressed the recommendations provided by the panel members. The panel members determined that the items they were asked to evaluate were face valid, construct valid, and content valid.

We used a pilot study to establish the reliability of the questionnaire. Prior to the launch of the pilot study, we obtained permission from the Iowa State University (ISU) Institutional Review Board (IRB). The questionnaire was constructed in Qualtrics and followed the Tailored Design Method for Internet Surveys (Dillman, Smyth, & Christian, 2014). We sent the questionnaire to 10 teachers selected from the 2017-2018 Iowa SBAE teacher directory.

Prior to the pilot study distribution of the questionnaire, we sent the 10 teachers a pre-notification message informing them about the pilot study and inviting them to be a part of it. A few days later, we sent the teachers a link to the questionnaire. Within one week, we received five completed questionnaires, yielding a response rate of 50%. One week after the teachers were sent the questionnaire link, we sent a reminder message to the five non-respondents. Within two weeks after the reminder message was sent, none of the remaining five teachers responded. We subsequently implemented the second round of the pilot study and randomly selected 10 additional teachers. Within one week, five more teachers completed the questionnaire, yielding a response rate of 50%. We used IBM Statistical Package for Social Sciences (SPSS©) Version 24.0 software to calculate a Cronbach’s alpha reliability coefficient for the 29 items that addressed teachers’ opinions about VR technology.

We used a standardized Cronbach’s alpha as the reliability coefficient (α = .940). As noted by Cohen, Manion, and Morrison (2011), standardization can be used for comparing items
that are composed of different scales. In our case, the teacher opinions about VR technology portion of the questionnaire consisted of a total of 29 items and includes: 25 items using the same five-point Likert scale, one item using a four-point scale Likert-type scale, two items using two different five-point Likert-type scales, and one item using a three-point Likert-type scale. Based on the interpretations given by George and Mallery (2003), the reliability coefficient was regarded as Excellent. After the conclusion of the pilot study, the panel members were asked to re-evaluate the items that addressed teachers’ opinions about VR technology to determine that each item was still face validity, construct validity, and content validity. All three panel members determined that the items they previously evaluated were still face valid, construct valid, and content valid.

Our design was a census study. We sent the questionnaire out to the entire population of SBAE teachers in Iowa ($N = 265$). Because we did not alter the questionnaire between the pilot study and the formal study, we decided to include the 10 pilot study participants in the data set reported in this manuscript. However, we did not re-send the questionnaire to the pilot study participants, thus reducing the number of teachers to whom we sent the formal study questionnaire to 255. To maximize the response rate, we followed the recommendations of Dillman et al. (2014) and incorporated five points of contact. Using Qualtrics, we sent a pre-notice e-mail to all the teachers within the population of interest ($n = 255$). A few days later, we sent them an e-mail containing the link to access the questionnaire. Over the next few weeks we sent two additional reminder e-mails to non-responders. These e-mails were spaced at least one week apart and were sent out early in the morning to allow teachers time before the school day started to respond. We deliberately elected to avoid sending out the reminder e-mails on either Monday morning or weekends. Our final reminder was a postcard sent by U.S. mail. The
postcard contained a reminder message, a web link to the questionnaire, and our contact information.

Ninety teachers provided usable data in the pilot and formal studies, yielding a response rate of 33.9%. As nonresponse error is considered an external validity threat in survey research (Ary et al., 2010; Lindner, Murphy, & Briers, 2001), we controlled this threat by comparing early and late responders. Because we could not identify a wave of late responders, we categorized the latter 50% of respondents as late responders in accordance with the recommendations of Lindner et al. (2001). Our use of an independent samples $t$-test on the 29 items related to teachers’ opinions about VR technology revealed no statistically significant ($p > .05$) differences between early and late responders. Thus, in accordance with Ary et al. (2010), “[we] can assume the respondents are an unbiased sample… [and] can thus generalize to the total group” (p. 409).

We used IBM SPSS© Version 24.0 software to analyze our data. Frequencies, percentages, means, medians, modes, and standard deviations were used to summarize the data. As noted by Boone and Boone (2012), Likert scale and Likert-type scale data can be appropriately analyzed using these descriptive statistics.

**Results**

The typical respondent was male ($f = 52; 57.8\%$), was 39.79 years of age ($SD = 13.37$), had taught for an average of 15.58 ($SD = 12.51$) academic years, primarily taught coursework at the high school level ($f = 89; 98.9\%$), and held a bachelor’s degree as his highest degree earned ($f = 52; 57.8\%$). (Table 1).
Table 1

*SBAE Teacher Demographics*

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<th>Item</th>
<th><em>f</em></th>
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<td>52</td>
<td>57.8</td>
</tr>
<tr>
<td>Master’s Degree</td>
<td>36</td>
<td>40.0</td>
</tr>
<tr>
<td>Education Specialist Degree</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>Doctorate Degree</td>
<td>1</td>
<td>1.1</td>
</tr>
</tbody>
</table>
The typical respondent’s SBAE program was located in a population area of at least 2,500 but less than 50,000 ($f = 60; 66.7\%$), was a single-teacher program ($f = 71; 78.9\%$) with an average enrollment size of 123 students ($SD = 123.80$), and most commonly included a classroom area ($f = 89; 98.9\%$), an agricultural mechanics laboratory ($f = 65; 72.2\%$), and / or a greenhouse / horticulture laboratory ($f = 56; 62.2\%$). (Table 2).

Table 2

**SBAE Program Demographics**

<table>
<thead>
<tr>
<th>Item</th>
<th>$f$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local Population Density</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 2,500</td>
<td>28</td>
<td>31.1</td>
</tr>
<tr>
<td>More Than 2,500 But Less Than 50,000</td>
<td>60</td>
<td>66.7</td>
</tr>
<tr>
<td>At Least 50,000</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td><strong>Number of Teachers in Program</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One</td>
<td>71</td>
<td>78.9</td>
</tr>
<tr>
<td>Two</td>
<td>14</td>
<td>15.6</td>
</tr>
<tr>
<td>Three</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Four</td>
<td>4</td>
<td>4.4</td>
</tr>
<tr>
<td>Did Not Indicate</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Approximate Program Enrollment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-50</td>
<td>21</td>
<td>23.3</td>
</tr>
<tr>
<td>51-100</td>
<td>33</td>
<td>36.7</td>
</tr>
<tr>
<td>101-150</td>
<td>18</td>
<td>20.0</td>
</tr>
<tr>
<td>151-200</td>
<td>4</td>
<td>4.4</td>
</tr>
<tr>
<td>200+</td>
<td>12</td>
<td>13.3</td>
</tr>
<tr>
<td>Did Not Indicate</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td><strong>Facilities Available for Use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom Area</td>
<td>89</td>
<td>98.9</td>
</tr>
<tr>
<td>Agricultural Mechanics Laboratory</td>
<td>65</td>
<td>72.2</td>
</tr>
<tr>
<td>Greenhouse / Horticulture Laboratory</td>
<td>56</td>
<td>62.2</td>
</tr>
<tr>
<td>Land Laboratory</td>
<td>46</td>
<td>51.1</td>
</tr>
<tr>
<td>Computer Laboratory</td>
<td>28</td>
<td>31.1</td>
</tr>
<tr>
<td>Aquaculture / Aquaponics Laboratory</td>
<td>16</td>
<td>17.8</td>
</tr>
<tr>
<td>Livestock Laboratory</td>
<td>10</td>
<td>11.1</td>
</tr>
<tr>
<td>Food Science Laboratory</td>
<td>3</td>
<td>3.3</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Meats Laboratory</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Data regarding teachers’ prior experiences with VR technology are reported in Table 3. The greatest frequency of responses was have seen in person ($f = 34; 37.8\%$).

Table 3

**SBAE Teachers’ Prior Experiences with VR Technology**

<table>
<thead>
<tr>
<th>Item</th>
<th>NPE</th>
<th>HSI</th>
<th>HSP</th>
<th>HSAPUI</th>
<th>HSAPUP</th>
<th>HUM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$f$ (%)</td>
<td>$f$ (%)</td>
<td>$f$ (%)</td>
<td>$f$ (%)</td>
<td>$f$ (%)</td>
<td>$f$ (%)</td>
</tr>
<tr>
<td>Which of the following describes your prior experiences with virtual reality technology?</td>
<td>21(23.3)</td>
<td>13(14.4)</td>
<td><strong>34(37.8)</strong></td>
<td>8(8.9)</td>
<td>18(20.0)</td>
<td>28(31.1)</td>
</tr>
</tbody>
</table>

*Note. Each respondent could have selected more than one response to this item. NPE = No Prior Experiences; HSI = Have Seen on the Internet; HSP = Have Seen in Person; HSAPUI = Have Seen Another Person Use on the Internet; HSAPUP = Have Seen Another Person Use in Person; HUM = Have Used Myself.*

Data regarding teachers’ perceived experiences they have had with using VR technology are reported in Table 4. The greatest frequency of teachers ($f = 49; 55.1\%$) reported that they have had *fairly positive* experiences with using VR technology.

Table 4

**SBAE Teachers’ Perceived Experiences Using VR Technology**

<table>
<thead>
<tr>
<th>Item</th>
<th>No Prior Experiences</th>
<th>Very Negative</th>
<th>Somewhat Negative</th>
<th>Fairly Positive</th>
<th>Very Positive</th>
<th>Did Not Indicate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$f$ (%)</td>
<td>$f$ (%)</td>
<td>$f$ (%)</td>
<td>$f$ (%)</td>
<td>$f$ (%)</td>
<td>$f$ (%)</td>
</tr>
<tr>
<td>Which of the following best describes any experiences that you have had with using virtual reality technology?</td>
<td>23(25.8)</td>
<td>2(2.2)</td>
<td>8(9.0)</td>
<td><strong>49(55.1)</strong></td>
<td>7(7.9)</td>
<td>1(1.1)</td>
</tr>
</tbody>
</table>

Responses to the 25 five-point Likert scale items that pertained to teachers’ opinions about VR technology are detailed in Table 5. The responses with the highest modes for each item are bolded. The item with the highest percentage of agree or strongly agree responses was “Virtual reality technology would increase my students’ interest in content at least some of the
time.” (81.1%). The item with the greatest percentage of unsure responses was “Virtual reality technology is only useful for psychomotor skill development.” (53.3%). The item with the highest percentage of disagree or strongly disagree responses was “Virtual reality technology is more of a gimmick or a game than an actual teaching tool.” (54.4%).
Table 5

**SBAE Teachers’ Opinions About VR Technology**

<table>
<thead>
<tr>
<th>Item</th>
<th>D %</th>
<th>U %</th>
<th>A %</th>
<th>Mdn</th>
<th>Md</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>My students are / would be comfortable trying to learn a new skill using virtual reality technology.</td>
<td>0.0</td>
<td>21.1</td>
<td><strong>78.9</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.93</strong></td>
<td>.596</td>
</tr>
<tr>
<td>My students enjoy / would enjoy using virtual reality technology in the classroom.</td>
<td>0.0</td>
<td>22.2</td>
<td><strong>77.8</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.93</strong></td>
<td>.614</td>
</tr>
<tr>
<td>My students are / would be comfortable trying to learn a new concept using virtual reality technology.</td>
<td>0.0</td>
<td>23.3</td>
<td><strong>76.7</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.92</strong></td>
<td>.622</td>
</tr>
<tr>
<td>Virtual reality technology would increase my students’ interest in content at least some of the time.</td>
<td>0.0</td>
<td>18.9</td>
<td><strong>81.1</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.90</strong></td>
<td>.520</td>
</tr>
<tr>
<td>I am familiar with the concept of virtual reality technology.</td>
<td>10.0</td>
<td>10.0</td>
<td><strong>80.0</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.87</strong></td>
<td>.851</td>
</tr>
<tr>
<td>There is great value in trying to learn a new skill using virtual reality technology.</td>
<td>3.3</td>
<td>25.6</td>
<td><strong>71.1</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.81</strong></td>
<td>.701</td>
</tr>
<tr>
<td>There is great value in trying to learn a new concept using virtual reality technology.</td>
<td>5.6</td>
<td>27.8</td>
<td><strong>66.7</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.76</strong></td>
<td>.769</td>
</tr>
<tr>
<td>Virtual reality technology can be used effectively in agricultural education classroom settings.</td>
<td>3.3</td>
<td>31.1</td>
<td><strong>65.5</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.74</strong></td>
<td>.712</td>
</tr>
<tr>
<td>My administration would have a positive opinion toward the use of virtual reality technology in my program.</td>
<td>4.4</td>
<td>30.0</td>
<td><strong>65.6</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.70</strong></td>
<td>.694</td>
</tr>
<tr>
<td>Virtual reality technology adds / could add value to my instructional approach.</td>
<td>10.0</td>
<td>21.1</td>
<td><strong>68.9</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.67</strong></td>
<td>.764</td>
</tr>
<tr>
<td>Virtual reality technology can be used effectively in agricultural education laboratory settings.</td>
<td>4.4</td>
<td>35.6</td>
<td><strong>60.0</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.67</strong></td>
<td>.734</td>
</tr>
<tr>
<td>I am comfortable trying to learn a new skill using virtual reality technology.</td>
<td>10.0</td>
<td>24.4</td>
<td><strong>65.6</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.64</strong></td>
<td>.783</td>
</tr>
<tr>
<td>I enjoy / would enjoy using virtual reality technology in my classroom.</td>
<td>8.9</td>
<td>33.3</td>
<td><strong>57.8</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.62</strong></td>
<td>.829</td>
</tr>
<tr>
<td>I am comfortable trying to learn a new concept using virtual reality technology.</td>
<td>10.0</td>
<td>25.6</td>
<td><strong>64.4</strong></td>
<td>4</td>
<td>4</td>
<td><strong>3.62</strong></td>
<td>.815</td>
</tr>
</tbody>
</table>
Table 5 (continued)

<table>
<thead>
<tr>
<th>Item</th>
<th>D %</th>
<th>U %</th>
<th>A %</th>
<th>Mdn</th>
<th>Md</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual reality technology is a useful method for psychomotor skill development.</td>
<td>5.6</td>
<td>37.8</td>
<td>56.7</td>
<td>4</td>
<td>4</td>
<td>3.61</td>
<td>.745</td>
</tr>
<tr>
<td>Virtual reality technology is too costly to use in my classroom.</td>
<td>6.7</td>
<td>40.0</td>
<td>53.3</td>
<td>4</td>
<td>3</td>
<td>3.60</td>
<td>.845</td>
</tr>
<tr>
<td>I have a positive opinion about virtual reality technology.</td>
<td>10.0</td>
<td>31.1</td>
<td>58.9</td>
<td>4</td>
<td>4</td>
<td>3.59</td>
<td>.847</td>
</tr>
<tr>
<td>Virtual reality technology would add more of a STEM focus to my program.</td>
<td>12.2</td>
<td>27.8</td>
<td>60.0</td>
<td>4</td>
<td>4</td>
<td>3.57</td>
<td>.822</td>
</tr>
<tr>
<td>Virtual reality technology use will increase as a method of psychomotor skill development.</td>
<td>5.6</td>
<td>50.0</td>
<td>44.4</td>
<td>3</td>
<td>3</td>
<td>3.43</td>
<td>.671</td>
</tr>
<tr>
<td>The potential benefits to incorporating virtual reality technology into my classroom outweigh the potential costs of the technology.</td>
<td>20.0</td>
<td>52.2</td>
<td>27.8</td>
<td>3</td>
<td>3</td>
<td>3.08</td>
<td>.782</td>
</tr>
<tr>
<td>My student treat / would treat virtual reality training as a game or gimmick rather than as an actual teaching tool.</td>
<td>28.9</td>
<td>42.2</td>
<td>28.8</td>
<td>3</td>
<td>3</td>
<td>3.01</td>
<td>.906</td>
</tr>
<tr>
<td>My administration would support me in funding virtual reality technology for my program.</td>
<td>22.2</td>
<td>52.2</td>
<td>25.6</td>
<td>3</td>
<td>3</td>
<td>2.98</td>
<td>.807</td>
</tr>
<tr>
<td>Virtual reality technology is more of a gimmick or a game than an actual teaching tool.</td>
<td>54.4</td>
<td>32.2</td>
<td>14.4</td>
<td>2</td>
<td>2</td>
<td>2.58</td>
<td>.887</td>
</tr>
<tr>
<td>Virtual reality technology is only useful for psychomotor skill development.</td>
<td>43.3</td>
<td>53.3</td>
<td>3.3</td>
<td>3</td>
<td>3</td>
<td>2.57</td>
<td>.619</td>
</tr>
<tr>
<td>My teaching methods / strategies would not benefit from the use of virtual reality technology.</td>
<td>53.3</td>
<td>32.3</td>
<td>15.1</td>
<td>2</td>
<td>2</td>
<td>2.57</td>
<td>.875</td>
</tr>
</tbody>
</table>

Note. Scale: 1 = strongly disagree (SD); 2 = disagree (D); 3 = unsure (U); 4 = agree (A); 5 = strongly agree; Mdn = Median; Md = Mode; M = Mean; SD = Standard deviation. Following the statistical analysis, strongly disagree and disagree were collapsed into the disagree column and strongly agree and agree were collapsed into the agree column.
Data regarding the teachers’ opinions about the importance to consider adding VR technology in SBAE programs are reported in Table 6. The greatest frequency of teachers (f = 43; 47.8%) reported that it was *slightly important* that teachers consider adding VR technology as an instructional component in their programs.

Table 6

**SBAE Teachers’ Opinions About the Importance to Consider Adding VR Technology in SBAE Programs**

<table>
<thead>
<tr>
<th>Item</th>
<th>Not Important</th>
<th>Slightly Important</th>
<th>Moderately Important</th>
<th>Very Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>How important is it for teachers to consider adding virtual reality technology as an instructional component within their agricultural education programs?</td>
<td>8(8.9)</td>
<td><strong>43(47.8)</strong></td>
<td>32(35.6)</td>
<td>7(7.8)</td>
</tr>
</tbody>
</table>

Data regarding teachers’ opinions about the quality of VR technology over time are reported in Table 7. The greatest frequency of teachers (f = 78; 86.7%) reported that the quality of VR technology has *improved* over the last five years.

Table 7

**SBAE Teachers’ Opinions About the Quality of VR Technology Over Time**

<table>
<thead>
<tr>
<th>Item</th>
<th>Declined</th>
<th>Neither Declined nor Improved</th>
<th>Improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>The quality of virtual reality technology has __________ over the last five years.</td>
<td>0(0.0)</td>
<td>12(13.3)</td>
<td><strong>78(86.7)</strong></td>
</tr>
</tbody>
</table>

Data regarding teachers’ opinions about their future plans to implement VR technology are reported in Table 8. The greatest frequency of teachers (f = 51; 56.7%) reported that they *possibly* plan to implement VR technology within their classrooms in the near future.
Table 8

*SAE Teachers’ Opinions About Future Plans to Implement VR Technology*

<table>
<thead>
<tr>
<th>Item</th>
<th>Definitely Not</th>
<th>Probably Not</th>
<th>Possibly</th>
<th>Probably</th>
<th>Definitely</th>
</tr>
</thead>
<tbody>
<tr>
<td>I plan to implement virtual reality technologies within my classroom in the near future.</td>
<td>3(3.3)</td>
<td>21(23.3)</td>
<td>51(56.7)</td>
<td>9(10.0)</td>
<td>6(6.7)</td>
</tr>
</tbody>
</table>

Data regarding teachers’ perceived frequency of incorporating new and emerging instructional technologies in their classrooms are reported in Table 9. The greatest frequency of teachers (f = 52; 57.8%) reported that they *occasionally* incorporated new and emerging technologies in their classrooms.

Table 9

*SAE Teachers’ Perceived Frequency of Incorporating New and Emerging Instructional Technologies*

<table>
<thead>
<tr>
<th>Item</th>
<th>Never</th>
<th>Rarely</th>
<th>Occasionally</th>
<th>Frequently</th>
<th>Very Frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>How frequently do you incorporate new and emerging instructional technologies in your classroom?</td>
<td>1(1.1)</td>
<td>2(2.2)</td>
<td>52(57.8)</td>
<td>29(32.2)</td>
<td>6(6.7)</td>
</tr>
</tbody>
</table>

**Conclusions, Discussion, Recommendations, and Implications**

The findings of our study indicated that Iowa SBAE teachers did, for the most part, view VR technology in a favorable light. Echoing Alston et al.’s (2003) findings, there was a considerable degree of uncertainty about the topic. Many teachers believed that they were familiar with VR technology, held positive opinions about the topic, and were receptive to possibly implementing VR technology into their SBAE programs. Most teachers opined that VR technology quality had improved over recent years and they perceived that they regularly incorporated new and emerging instructional technologies within their SBAE programs. Many
teachers indicated that they believed their students could be effectively engaged in the learning process by using VR technology as an instructional medium and that VR technology could positively impact their SBAE programs. Many teachers indicated they believed that VR technology was a valuable and useful instructional approach that could be used for a wide range of purposes and settings in SBAE.

While most teachers indicated that VR technology is useful for psychomotor skill development, many teachers were also uncertain about whether VR technology could be useful beyond just teaching psychomotor skill-oriented content and whether the technology’s usage for psychomotor skill development will increase. Though many teachers did express that they had positive prior experiences with VR technology, they also believed that VR technology was too costly for them to acquire and implement into their respective SBAE programs, thus indicating that the financial burden of acquiring VR technology is a primary barrier. The cost of technology applications has been identified as a barrier to adoption by other researchers (Alston et al., 2003; Coley et al., 2015; Williams et al., 2014b).

Williams et al. (2014b) noted that SBAE teachers are generally supportive of incorporating educational technologies into their programs, which echoed the sentiments that we found about VR technology. Anderson and Williams (2012) noted that teachers often have favorable attitudes toward using different types of technologies for educational purposes. Considering these ideas along with the results of the present study, we anticipate that VR technology adoption may begin to increase as VR technology application diversity increases, becomes more affordable, and increases in relevance. Bailenson (2018) predicted that these factors will soon begin to happen more rapidly.
When viewed through the lens of our adapted version of Fishbein and Ajzen’s (2010) reasoned action model, we focused specifically on how intentions and behaviors can be shaped and informed by a variety of factors, such as prior experiences, personal beliefs, and so forth. Through examining SBAE teachers’ opinions about VR technology, we believed that opinions could very well influence intentions and use of VR technology. As noted by Fishbein and Ajzen (2010), human behaviors are complex processes that are developed through numerous contexts and lenses. Based on the findings of our study, we believe that while teachers held mostly positive opinions about the topic, the considerable degree of uncertainty they exhibited may yield a mixture of resulting behaviors regarding VR technology adoption and use. Individual opinions about a topic are a background factor that impacts a behavior (Fishbein & Ajzen, 2010). Understanding what those opinions are can be useful to identifying courses of action that agricultural teacher educators, SBAE teachers, and hardware and software developers should take when working to develop and implement VR technology.

We recommend that SBAE teachers engage in professional development opportunities in which VR technology is being used to help increase exposure and generate ideas for applying the technology in their programs. Teachers who are interested in using VR technology in their own programs should consider pursuing grants funds from educational foundations and community organizations. SBAE teachers who wish to use VR technology in their programs should also consider using funding from the Carl D. Perkins Career and Technical Education Act to facilitate VR technology purchases.

We also recommend that teacher educators with interests in educational technology work to develop their own knowledge and skills related to VR technology applications in SBAE settings. Doing so will help to facilitate the further inclusion of opportunities for education about
the subject for preservice teachers via coursework and for inservice teachers via professional development opportunities. In terms of using VR technology in teacher education coursework, teacher educators could consider developing learning experiences that employ the technology in various ways. For example, an agricultural teacher educator who teaches an undergraduate-level agricultural mechanics course that includes weld process training could employ a VR welding system to help preservice teachers develop their welding-related psychomotor skills and expose them to a VR technology application that could be very practical for SBAE programs. The same agricultural teacher educator may continue this approach in a weld process training professional development session for inservice teachers. Funding to support such opportunities could come from a variety of sources, including university technology acquisition funds, private donors, and industry-based support.

We recommend that additional exploration of this topic be conducted with other groups of SBAE teachers from across the United States. Doing so will help the profession to develop a deeper understanding of SBAE teachers’ opinions about VR technology. While we imagine much of this research would be of a quantitative nature, the value of qualitative research should not be understated either. Qualitative inquiry studying SBAE teachers who currently implement VR technology in their programs could help to provide a more in-depth examination of the specific VR technology applications that teachers are using as well as exactly how they are being used for educational purposes. As noted by Bailenson (2018), the possibilities for VR technology application development and implementation are practically endless and new opportunities for expansion are regularly being identified. Qualitative and quantitative inquiry could also be used to examine the impacts that using VR technology as an instructional approach has on students.
Regarding our study’s implementation, our response rate of 33.9% left us with some questions. As we followed Dillman et al.’s (2014) methods for implementing Internet-based survey research, we wondered what factors may have contributed to the lack of response from the broader population of 265 SBAE teachers throughout Iowa. Perhaps SBAE teachers’ lack of interest in the topic, teachers’ workloads with FFA activities, or other obligations may have negatively impacted our response rate. It is also conceivable that the non-responding teachers may have been unfamiliar with the topic and thus felt that their contributions to the study’s data set would have been minimal. We found that non-response error was not an issue and we can generalize our results to all Iowa SBAE teachers in accordance with Ary et al. (2010). However, we acknowledge that we cannot generalize our results beyond Iowa SBAE teachers.

As the SBAE teachers in our study opined that the cost of VR technology is too great, this may be a barrier that is currently limiting the adoption of VR technology. Future studies to identify additional barriers and decision-making factors regarding VR technology adoption and use should be conducted. While barriers to educational technology usage by SBAE teachers do exist (Coley et al., 2015), technology adoption and use must be emphasized to help maintain effective instruction within SBAE programs (Kotrlik et al., 2003). Failure to effectively implement educational technologies could compromise opportunities to provide adequate educational experiences within technical agriculture content (Kotrlik et al., 2003).

We recommend that future studies expand and include educational technologies beyond VR, such as augmented reality (AR) and mixed reality (MR), to continue to build upon the educational technology literature. As the rate of technological change continues to increase each year (Bailenson, 2018), it is vital that the agricultural education profession remains able to keep pace with new developments. Educational technologies that can serve to assist with better
educating the public at large as well as students in all types of agricultural education settings should be better understood to maximize their utility (Lindner et al., 2016).

**References**


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)


CHAPTER 4. STUDENTS’ PERSPECTIVES ON USING VIRTUAL REALITY TECHNOLOGY IN A UNIVERSITY-LEVEL AGRICULTURAL MECHANICS COURSE

A paper prepared for submission to the *Journal of Agricultural Education*

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Abstract

Simulator technologies have become more prominent in many educational contexts in recent years (Kneebone, 2005; Winn & Jackson, 1999). Simulator technologies such as virtual reality (VR) exist in many forms and can be used for different purposes (Thiagarajan, 1998), including weld process training (Stone, Watts, Zhong, & Wei, 2011). University-level students have previously reported that using VR technology can positively contribute to a course experience (Tiffany & Hoglund, 2014). Limited data exist regarding students’ perspectives of using VR technology to develop welding-related psychomotor skills in a university-level agricultural mechanics course. Through two focus groups conducted during the Spring 2018 semester, this phenomenological study sought to describe the perspectives that nine students had on using a VR technology application during their weld process training. Students indicated that while using a VR technology application can be useful, it should not take the place of using actual welding equipment as part of the educational experience. The authors recommend that faculty who are considering using a VR technology application should carefully analyze current instructional needs to ensure that using VR technology will adequately address students’ educational requirements and will complement live weld process training procedures.

Introduction

Educational technologies include various types and applications that are meant to achieve a wide range of different purposes and goals (Saettler, 2004; Smith, Stair, Blackburn, & Easley,
Educational technologies can include smartphones (Smith et al., 2018), digital games (Amory, Naicker, Vincent, & Adams, 1999), and simulator technologies (Scalese, Obseo, & Issenberg, 2008). Regarding simulator technologies, Thiagarajan (1998) noted that “[a] simulation [emphasis in original] is a representation of the features and behaviors of one system through the use of another” (p. 35). In recent decades, simulator technologies have become more prominent within many educational contexts (Kneebone, 2005; Winn & Jackson, 1999). More specifically, simulators can, when used properly, serve as useful educational interventions (Abrams, Schow, & Riedel, 1974; Kneebone, 2005; Nikolic, Radivojevic, Djordjevic, & Milutinovic, 2009; Thiagarajan, 1998; Winn & Jackson, 1999). Additionally, Thiagarajan (1998) noted that simulator technologies exist in many different forms and can be used for many different purposes.

As noted by Hertel and Millis (2002), using simulations in an educational setting can help to invoke within students a greater sense of motivation and subsequently promote deeper, more thorough learning of subject matter. The use of simulator technologies can help to positively impact the teaching and learning processes (Abrams et al., 1974; Scalese et al., 2008). As an example of a simulator technology type, using VR technology in the context of educational settings has long been identified as useful and viable (Youngblut, 1998). Much progress has been made regarding the advancements of VR technology (Bailenson, 2018; Brooks, 1999), especially considering the diversity of fields that VR technology has been applied in. Throughout the past three decades, VR technology has been studied in the contexts of: (1) weld process training (Byrd, 2014; Byrd, Stone, Anderson, & Woltjer, 2015; Stone, McLaurin, Zhong, & Watts, 2013; Stone, Watts, Zhong, & Wei, 2011), (2) medical science (Cope & Fenton-Lee, 2008; Gallagher et al., 2003; Gor, McCloy, Stone, & Smith, 2003; Kilmon, Brown, Ghosh, & Mikitiuk, 2010;
Seymour et al., 2002), (3) safety training (Filigenzi, Orr, & Ruff, 2000), (4) science education (Nadolny, Woolfrey, Pierlott, & Kahn, 2013), and (5) first responder training (Bliss, Tidwell, & Guest, 1997). VR technology has great potential to positively impact the educational experience (Bailenson, 2018), particularly in laboratory-based settings (Potkonjak et al., 2016) such as a university-level agricultural mechanics course.

Regarding experience as a teaching tool, Dewey (1916, 1938) noted that the development of an individual’s education through experiences is an invaluable source of learning so long as the experiences are effective and of adequate quality. Jarmon, Traphagan, Mayrath, and Trivedi (2009) noted that learning via experience and reflecting on that experience (i.e., experiential learning) can be quite impactful when using VR technology in a university-level course. Experiential learning, as described by Kolb (2015), is a four-cycle process through which an individual actively engages in the creation and refinement of new knowledge. These four cycles are: (1) concrete experience, (2) reflective observation, (3) abstract conceptualization, and (4) active experimentation.

VR technology can allow for individual users to effectively engage in each of Kolb’s cycles. As an example of a VR technology application, a VR welding system can be used to allow students a concrete experience by performing a series of virtual 2F position tee joint welds using the shielded metal arc welding (SMAW), gas metal arc welding (GMAW), or flux-cored arc welding (FCAW) process. The VR welding system can facilitate reflective observation by providing critical feedback on welding skill performance by using different progress representations such as charts, graphs, numerical scores, and replay functions that users can view to help determine welding technique successes and shortcomings. Users could then employ abstract conceptualization by interpreting the feedback data to improve their welding techniques
and determine exactly how best to proceed. Afterward, users could engage in active experimentation by performing additional virtual 2F position tee joint welds and altering their welding techniques to address the shortcomings previously detailed in the data received from the VR welding system. The experiential learning process begins anew as users complete additional virtual welds, assess their techniques, develop new ideas about how to proceed, and further experiment with different welding techniques.

Within university-level settings, Jarmon et al. (2009) noted that VR technology can be beneficial to student learning, particularly from the standpoint of the experiential learning process. Incorporating VR technology into university-level coursework with a significant degree of practical, hands-on applications can prove beneficial in multiple ways, including the opportunity to make mistakes without actual physical harm or damage, to experiment with procedures and methods, and to develop expertise within a topic or concept (Häfner, Häfner, & Ovtcharova, 2013). For example, medical schools have incorporated VR technology into their curricula as a means of supplementing work with actual clientele (Verdaasdonk, Stassen, van Wijk, & Dankelman, 2007). This helps to minimize risks that can occur when working with physical entities such as actual patients.

VR technology used in the context of welding skill development has shown promise in helping users to successfully refine welding techniques (Stone et al., 2011). Perhaps using a VR technology application could be a practical approach to teaching and learning in a university-level course focused on skill development. Considering that prior research (Byrd, 2014; Stone et al., 2011) has indicated that VR technology can help to effectively develop welding-related psychomotor skills, how would students perceive using such tools in a university-level course setting?
Spicer and Stratford (2001) noted that students in university-level settings often find value in using VR technology to help supplement the learning experiences offered in their coursework. Tiffany and Hoglund (2014) noted that future nurse-educators who had enrolled in a graduate-level nursing education course frequently perceived using VR technology to be a valuable aspect of the learning process. Thus, evidence implies that students see value in this approach to teaching and learning. Lancelot (1944) suggested that capturing student interest and maintaining engagement are key factors to providing effective instruction. Understanding student perspectives on using an instructional approach can be beneficial for increasing student investment in the learning process by helping course instructors to adapt instruction as necessary to achieve defined teaching and learning objectives (McCubbins, Paulsen, & Anderson, 2016).

Prior exploration of users’ perceptions of VR welding systems has been conducted outside of university settings. Porter, Cote, Gifford, and Lam (2005) noted that most users of such systems expressed positive sentiments toward using the technology for educating novices. Yunus, Baser, Masran, Razali, and Rahim (2011) found that the majority of weld process trainees perceived that the welding skill development process can be positively impacted by using a VR technology application. In contrast, Fast, Jones, and Rhoades (2012) noted that users of an in-development VR welding system reported a substantial amount of negative feedback and indicated a lack of realism associated with the technology. Interestingly, the users in Fast et al.’s (2012) study ranged from novice welders to instructors, indicating that individuals from differing backgrounds found the VR welding system to be an inadequate source of skill development due to several factors. These conflicting findings raise some interesting questions, particularly when considering how students in a semester-long, university-based agricultural mechanics course may perceive using a VR welding system.
Students in university-level coursework often perceive that using VR technology for teaching and learning purposes can be beneficial to the course experience (Spicer & Stratford, 2001; Tiffany & Hoglund, 2014). However, limited research focusing on students’ perspectives of using VR technology for welding skill development in a university-level course has been conducted. As such, a gap in the literature currently exists. While prior research (Fast et al., 2012; Porter et al., 2005; Yunus et al., 2011) has indicated that different user groups do exhibit conflicting perspectives about using VR technology for skill development purposes, an examination into the perspectives of university students who were in the process of developing their welding-related psychomotor skills could be useful. As university students enrolled in semester-long agricultural mechanics coursework often engage in weld process training (Burris, Robinson, & Terry, 2005), what insights into the welding skill development process could these students provide when considering the use of VR technology? How might these insights impact the adoption of VR welding systems into agricultural education settings more broadly?

**Theoretical Framework**

This study was underpinned by Fishbein and Ajzen’s (2010) reasoned action model. This model was used to guide the analysis and categorization of student responses. Fishbein and Ajzen (2010) indicated that behaviors are driven by prerequisite factors. These factors include individual-specific factors such as attitudes and prior behaviors, broader social factors that include education, and information-specific items such as previous knowledge. In accordance with the reasoned action model, these factors influence beliefs, attitudes, and perceptions regarding behaviors, social norms, and controls, all of which drive intentions and can influence behavior. Actual control, which includes individuals’ skills / abilities and present environmental factors, can also impact perceptions of behavioral control and influence behaviors.
The behavior of interest in the present study, students’ use of a VR welding system to develop welding-related psychomotor skills in a university-level agricultural mechanics course, can be better understood through an in-depth exploration into students’ perspectives on the topic. Behaviors are complex and informed by numerous occurrences and concepts (Fishbein & Ajzen, 2010). In addition, motivating students to perform behaviors and engage in learning can be challenging (Lancelot, 1944; Phipps, Osborne, Dyer, & Ball, 2008). Thus, understanding individual students’ perspectives could help to more thoroughly define how VR technology usage can fit into course-based weld process training procedures. This knowledge could be used to create strategies to appeal to students’ interests in the topic and help to further refine the skill development process within university-level agricultural mechanics coursework.

**Research Questions and Purpose**

Based on the preceding literature and Fishbein and Ajzen’s (2010) reasoned action model, three central research questions emerged that guided this study:
1) What are the perspectives of students enrolled in a university-level agricultural mechanics course regarding the value of using VR technology as a welding skill development method?

2) What are the perspectives of students enrolled in a university-level agricultural mechanics course regarding perceived barriers to using VR technology during the weld process training portion of the course?

3) What are the perspectives of students enrolled in a university-level agricultural mechanics course regarding the benefits of using VR technology during the weld process training portion of the course?

Based upon these research questions, the purpose of the present study was to explore the perspectives that students enrolled in a semester-long, university-level agricultural mechanics course had on using a VR welding system for weld process training purposes, which aligned with the American Association for Agricultural Education (AAAE) National Research Agenda (NRA) Research Priority Area 4: Meaningful, Engaged Learning in All Environments (Edgar, Retallick, & Jones, 2016). When considering the research questions, the authors sought to examine if incorporating a VR-based instructional approach for weld process training in a course was, from the student perspective, useful and effective for developing welding-related psychomotor skills. Course instructor behaviors, such as implementing a VR technology application as part of the course design, can have important ramifications for students’ experiences in a course (Estepp & Roberts, 2013), particularly when establishing student interest and long-term engagement in the learning process (Lancelot, 1944). Identifying effective methods for engaging students in high-quality teaching and learning experiences is a primary goal of agricultural education practitioners and scholars (Edgar et al., 2016).
Methods

Qualitative research methods were used to achieve the research purpose. The present study was phenomenological in its approach. As noted by Creswell and Poth (2018), “a phenomenological study describes the common meaning for several individuals of their lived experiences of a concept or phenomenon” (p. 75). The phenomenon in the context of the present study was university-level agricultural mechanics course students’ experiences using VR technology as a method of developing welding-related psychomotor skills during the weld process training portion of the course. The lead researcher, Hank (pseudonym), followed the recommendations provided by Creswell and Poth (2018) to conduct this study, including using multiple in-depth focus group interviews with several individuals who each experienced the phenomenon and by using phenomenological data analysis procedures. Hank worked under the supervision of Gus (pseudonym), his major professor and a co-author of this study.

Upon Iowa State University (ISU) Institutional Review Board (IRB) approval, Hank followed Morgan and Krueger’s (1998) participant recruitment recommendations and began to solicit student participants via e-mail and in-class announcements. The recruitment e-mail was sent to the students on March 29, 2018, which was at least two weeks prior to the initial proposed date for the first focus group session. The e-mail contained information about the study and asked students to use a Doodle poll to designate potential focus group times and dates that fit their individual schedules. Hank wanted to establish a common time for each focus group session to take place based on the students’ availabilities. To help incentivize participation, food and drink were offered to all students in exchange for their time. Reminder e-mails and text messages were also sent to the students who elected to participate one day before each focus group session to help ensure maximum participant turn-out.
Hank sought to conduct at least two focus groups on the topic over the course of the Spring 2018 semester. According to Grudens-Schuck, Allen, and Larson (2004) and Morgan and Krueger (1998), the use of multiple focus group sessions can help to deepen understanding about a topic. The first focus group session consisted of six students and was conducted on April 11, 2018, while the second focus group session consisted of three students and was conducted on April 12, 2018. Hank and Gus acknowledged Krueger and Casey’s (2000) recommendations on focus group sizes, who stated, “[t]he ideal size of a focus group for most noncommercial topics is six to eight participants” (p. 73). While the first focus group session met the size recommendations offered by Krueger and Casey (2000), the second one did not.

To better inform the reader about the context of the study in its entirety, a brief description of each participant is provided. Pseudonyms were used to protect the students’ identities. The first six of these individuals participated in the first focus group session while the final three participated in the second focus group session.

**Focus Group Session One**

**Ryan** was an undergraduate student majoring in Agricultural Studies who grew up on his family’s farm and planned to return home to farm upon graduation. He enrolled in the course to improve his knowledge and skills related to small gas engines and welding.

**Tucker** was an undergraduate student majoring in Agricultural Studies who, like Ryan, came from a production agriculture background and intended to return home to farm upon graduation. He sought to develop mechanical skills that he could use to maintain equipment.

**Walter** was an undergraduate student majoring in Agricultural Studies and desired to return to his family’s farm after he finished his degree program. He was primarily interested in the small gas engines portion of the course.
Coulter was an undergraduate student majoring in Agricultural Studies who wanted to either return home and farm or pursue a position in agricultural sales and service. He wanted to take advantage of his course experience to improve his competencies in welding and small gas engine service.

Marie was an undergraduate student majoring in Agricultural and Life Sciences Education who planned to become a school-based agricultural education (SBAE) teacher in the Midwest. Her career plans included teaching agricultural mechanics content in her own SBAE program someday. She was motivated to enroll in the course to improve her technical agricultural mechanics knowledge and skills.

Jesse was an undergraduate student majoring in Agricultural Studies who, like Coulter, desired to either return home to his family’s farm or pursue a career in agricultural sales and service. He greatly valued the hands-on projects used in the course and frequently spent extra time working to improve his skills related to welding and small gas engines.

Focus Group Session Two

Kevin was an undergraduate student majoring in Mechanical Engineering who intended to pursue a career within an engineering research and development division of a corporation. He was motivated to enroll in the course due to his desire for a practical, hands-on course that was designed to link theory and application.

Lauren was an undergraduate student majoring in Agricultural and Life Sciences Education who sought to pursue a position as communications specialist in the agricultural industry upon graduation. She had previously completed agricultural mechanics coursework while she was a secondary student and, based upon her positive experiences therein, elected to enroll in the course to enhance her welding skills.
Wayne was an undergraduate student majoring in Agricultural Studies whose background was in production agriculture. He wanted to return to his family’s farm. His interest was in developing his abilities to maintain and repair various pieces of agricultural equipment to help conserve funds in the farm’s budget.

Due to Hank’s prior experiences with using the VR welding system in the course and because he could most appropriately address the purpose of the present study, he chose to moderate each focus group session, which lasted approximately 90 minutes based on the recommendations of Grudens-Schuck et al. (2004). Another doctoral student in the Department of Agricultural Education and Studies, Mike (pseudonym), who was neither a co-author of this study nor was affiliated with the course or its students, took observation notes. These written notes were, as detailed by Krueger and Casey (2000), intended to provide a more complete record of the focus group session, including participants’ quotes, behaviors, mannerisms, and so forth, as well as to further enhance trustworthiness of the present study’s findings.

It should be recognized that because Hank moderated the focus group sessions and was also the course instructor, concerns of potential bias and power over the course students were considered. To help address these concerns, neither participation in the focus group sessions nor thoughts shared during each focus group session were tied to course grades or affected their relationship with Hank. Course students were informed that their participation held no consequence toward their performance in the course and that their perspectives would be used to help further improve the use of VR technology in the course structure in the future. Mike’s presence in each focus group session as a third-party individual who was not a co-author of this study helped to monitor and assess for any bias in the way Hank phrased each question (e.g., using positive voice inflections on some questions, using negative tones with other questions,
etc.). Mike was provided with a printed copy of interview questions to read along with during each focus group session. Mike reported that he detected no bias in Hank’s moderation of each focus group session.

During each focus group session, Hank used a printed copy of interview questions, which included the leading questions in Table 1 and several probing questions. The use of a printed interview protocol helped to reduce the risk of bias when asking questions during each focus group session.

Table 1

<table>
<thead>
<tr>
<th>Interview Question</th>
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<tbody>
<tr>
<td>1. What value do you perceive in using the VR weld training system as part of the course’s weld training protocol?</td>
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<tr>
<td>2. What barriers, from a student perspective, exist to effectively using the VR weld training system as part of the course’s weld training protocol?</td>
</tr>
<tr>
<td>3. What benefits, from a student perspective, exist to using the VR weld training system as part of the course’s weld training protocol?</td>
</tr>
<tr>
<td>4. In future semesters of the course, what could be done to improve the experience of using the VR weld training system as part of the course’s weld training protocol?</td>
</tr>
</tbody>
</table>

These questions were developed prior to the focus group sessions and were reviewed for face and content validity by an SBAE teacher with prior experience using a VR welding system and by a qualitative research methods course instructor at ISU whose research focus was educational technology use. These individuals made suggestions to provide greater clarity to the leading interview questions and the probing questions. These suggestions included wording changes and sequencing of the questions. After the suggested changes to the questions were made, the questions were submitted back to them for a second review; they each determined the interview questions were both face valid and content valid and were appropriate for the present study.
In compliance with ISU IRB protocol, the course students were required to sign an informed consent document and return it to Hank prior to the start of each focus group session. Each student was also given an additional copy of the informed consent document to keep. Afterward, Hank began moderating the focus group sessions, taking care to follow the interview protocol and asking probing questions as needed. Each focus group session was conducted in Curtiss Hall and was audio- and video-recorded by staff working with the Brenton Center for Agricultural Instruction and Technology Transfer (BCAIT). The staff members operated the audio- and video-recording equipment and assisted with any technical issues that arose with the recording process. At the end of each focus group session, both Hank and Mike debriefed about the focus group session to discuss important concepts and ideas that emerged during each one. All audio- and video-recorded data were downloaded from the BCAIT’s computer system onto an encrypted portable hard drive and were subsequently sent to Rev, an off-campus transcription service not affiliated with ISU. Both focus group sessions’ transcripts were returned to Hank and the assigned pseudonyms were applied to the transcripts to protect each student’s identity.

After the conclusion of each focus group session, all student participants were sent an e-mail inviting them to participate in a follow-up focus group session to discuss the activities of their respective focus group sessions. This e-mail included a link to a Doodle poll to designate potential follow-up focus group times and dates that fit their individual schedules. Hank desired to establish a common time for each follow-up focus group session to take place based on the students’ availabilities.

Based on the results of the Doodle poll, Hank and Mike conducted two 30-minute follow-up focus group sessions seven days after each initial focus group session. Prior to these follow-up focus group sessions, Hank and Mike thoroughly read through all transcripts and observation
notes to identify “sentences, or quotes that provide an understanding of how the participants experienced the phenomenon” (Creswell & Poth, 2018, p. 79), potential emerging themes, and other pertinent data to share during each follow-up focus group session. The first follow-up focus group was on April 18, 2018 while the second one was on April 19, 2018, respectively. All six students who participated in the first focus group session attended their respective follow-up focus group session while only two of the three students who participated in the second focus group session attended their respective follow-up focus group session.

These follow-up focus group sessions were meant to serve as a member check procedure. As described by Maxwell (2013), member checking is a validity procedure that “is systematically soliciting feedback about your data and conclusions from the people you are studying” (p. 126). To accomplish this, Hank and Mike “convene[d] a focus group made up of the participants in the study and ask them to reflect on the accuracy of the account” (Creswell & Poth, 2018, p. 261). The student participants were not shown any transcripts, observation notes, or video evidence, but were instead shown “preliminary analyses consisting of description or themes” (Creswell & Poth, 2018, p. 262).

Regarding the data analysis process, Hank and Mike began the data analysis process by first independently reading through the focus group transcripts and observation notes and viewing the recorded videos of each focus group session several times, taking notes (memos) and highlighting important statements and ideas during each reading. Completing this process independently helped to enhance the credibility of the present study via triangulation (Creswell & Poth, 2018). As noted by Maxwell (2013), “[t]his strategy reduces the risk of chance associations and… allows a better assessment of the generality of the explanations” (p. 128). Creswell and Poth (2018) suggested that “corroborating evidence from different sources [can be
used] to shed light on a theme or perspective” (Creswell & Poth, 2018, p. 260). As noted by Maxwell (2013), memos “capture your analytic thinking about your data… facilitate [emphasis in original] such thinking, stimulating analytic insights” (p. 105). These memos helped to clarify both Hank’s and Mike’s thoughts during the data analysis phase and allowed for improved organization when advancing to the theme development stage, during which open coding procedures were used. Open coding helped to create large categories that were used to identify emerging themes (Creswell & Poth, 2018). As described by Creswell and Poth (2018), “themes… are broad units of information that consist of several codes aggregated to form a common idea” (p. 328).

As the lead author of this study, Hank established transferability through rich, thick descriptions of the context, participants, and environment. Such writing helped to present to the reader a greater sense of presence within the study itself, enhancing the depth and feel of the research and reading experiences (Creswell & Poth, 2018). Further, Hank, Gus, and Mike felt that it was important to provide insight into their potential biases. Bracketing beliefs about teaching with VR technology helped Hank, Gus, and Mike to “take a fresh perspective toward the phenomenon under investigation” (Creswell & Poth, 2018, p. 78). Providing insight into the Hank’s, Gus’s, and Mike’s prior experiences, values, and biases helps to aid the present study’s readers to understand the inquiry perspective (Creswell & Poth, 2018).

Hank was the agricultural mechanics course instructor and a former SBAE teacher who extensively taught introductory-level agricultural mechanics content (e.g., welding, woodworking, electricity, etc.) in a single-teacher program at a rural high school in western Alabama. Prior to serving as the course instructor, Hank did not use any VR technology as part of his instructional approach. Gus is a former SBAE teacher who taught agricultural mechanics
curricula and is an agricultural teacher educator who had taught several former, current, and future university-level agricultural mechanics course students in his SBAE program planning course, which is currently taught in the fall semester of each academic year. He had little prior experience with teaching using VR technology and did not use any VR technology as part of his instructional approach in his course.

Mike, who assisted with the data collection and analysis processes, earned his undergraduate degree in Agricultural Studies at ISU and did not take the university-level agricultural mechanics course as part of his undergraduate studies. He served as a crop insurance adjuster for a local agribusiness in central Iowa prior to initiating his doctoral studies. He taught one section of an agricultural communication strategies course and had little prior experience with teaching using VR technology. He did not use any VR technology as part of his instructional approach in his course. Through following these methods and providing substantial details about the research processes, Hank, Gus, and Mike were better able to improve the trustworthiness of the present study’s findings.

Results

The students were very willing to share their perspectives on using VR technology in the course. Interestingly, the results were quite mixed, as the students found value in the VR technology approach but were critical of its limitations, such as the ability to selectively cheat the VR welding system and earn a high score on a virtual weld exercise. The data interpretation process yielded three distinct emerging themes, which are detailed below.

Theme One: Alignment Between VR Welding and Live Welding

Within each focus group session, there was much discussion about the alignment between using the VR welding system to perform a virtual weld and using an actual welding machine to
complete a real, physical weld. In particular, the students were frequently concerned with limitations experienced when using the VR welding system. Ryan noted, “Sure it’s hands-on, but you’re not actually doing it.” Walter felt that he didn’t perform as well when using the VR welding system as he did when welding in a physical welding booth using an actual welding machine, describing that, “I’ve found out that actually doing the welding techniques is a lot different in some ways. I feel like I was a lot better doing it in real life as compared to the virtual reality.”

Jesse felt that the scores he was achieving when using the VR welding system were in conflict with the scores he had earned with the physical welds he submitted for grading in class, expressing that, “My grades with the [VR welding system], my grades with the real weld, there's quite a bit of difference in between. I don't know if the [VR welding system], for me, if it's really helping me or if it's really hurting me.” Tucker felt that students with a considerable level of welding experience are probably not as thoroughly impacted by using the VR welding system as a student who has little or no experience welding. He said, “I think maybe for a first timer, it's a good tool. They can see what it's all about. See what proper angles are and everything.” Other students supported this sentiment, with Marie expressing that, “[T]he [VR welding system] actually did help me with [determining] my proper [work and travel] angles. Other than that, it's really hard because you can't see your physical hands when you have the helmet on.”

Kevin honed in on differences between VR welding and live welding, noting that, “You don't feel the heat. And that's not there in the virtual [welding]. But there's definitely things that transfer very well over to actual welding in the virtual [welding].” Ryan went on to describe a limitation he felt was important when talking about physically handling welds and looking them over to inspect for quality issues:
I think [one thing that] is a barrier is you can't physically pick up the weld, you can't look at the penetration. You can turn it around [using the VR welding system inspection features] but you can't look on the bottom side.

Coulter believed that, "The biggest barrier is the correlation between the [VR welding system] and just real welding. I don't think it correlates what you actually have to do when you weld for real”, further explaining that he felt his performance when using the VR welding system was not reflective of his actual welding abilities. Marie felt that some elements of the VR welding system did not fit with actually preparing to perform the welding process, expressing that, “[T]he other day when I went to MIG weld I totally forgot to turn the gas tank on… [s]o it doesn't teach you to turn on the gas. It has you set it, but it's not that physical turning it on.”

While the students extensively discussed limitations they felt were hindering to the weld process skill transference, there were several acknowledgements that using VR technology was beneficial, particularly when considering operator-related variables that impact weld quality, such as travel speed, travel angle, work angle, and so forth. Coulter expressed he felt the system provided adequate feedback during the welding process itself through the use of visual cues, noting that, “I think that one good thing that the [VR welding system] brings to the table is the work angles and showing you what you're doing wrong and how you need to fix it with the little icons [visual cues] that you can display on your eye set.” Walter opined that, “The [VR welding system] helped me with my body position[ing] [and] [a]lso with my timing.” Walter further noted that, "[I]t helped ease into the transition of doing it in [the] real world.”

Wayne offered that, “The angles and all that stuff were really compatible.” Jesse felt that the simulation effect was quite beneficial in terms of learning how to set up a welding machine, noting that, “[I]t does help [with] setting a welder up with gas pressure and with wire feed and
heat and stuff like that. How to switch it over [to another welding process]. It does help with some knowledge about that.” In response to Jesse, Coulter felt that, “Just getting the feel of everything helps translate over to a real welder.” In terms of perceived beneficence, the students’ notations revolved primarily around how the VR welding system was the most useful with helping them to better understand how to improve their own body positioning and movements when performing a weld.

Theme Two: Utility as a Tool for Teaching and Learning

Between both focus group sessions, the students spent a significant amount of time alluding to the VR welding system’s utility as a tool for teaching and learning. The comments were a mixture of positive and negative remarks, though the students did note several positive attributes for using VR technology for teaching and learning purposes. For example, when probed about any specific ways using the VR welding system affected his welding performance, Walter said, “I think it just helped me with timing. Taking my time with the [VR welding system], I think doing that showed me that I really needed to slow down to fill in my welds.” Kevin echoed this idea and stated, “I think this one [the VR welding system] did a pretty good job of simulating it [the welding process] at least.” Several students believed that saving consumable materials was a benefit to using VR technology for teaching purposes. Wayne capitalized on this discussion and stated, “I think it's beneficial because it uses no [consumable] material. Just plug it [the VR welding system] in and go.” Marie acknowledged that saving on consumable materials was a valuable factor itself, as she stated, “[Y]ou're not wasting as much metal on those first few mess-up welds. That's one big thing I can see of value out of it.”

Students agreed that using the VR welding system to introduce the concepts of welding could be a useful approach for students with limited or no welding experience, particularly
through quelling anxious students’ fears about welding for the first time and for helping students to adjust their welding technique. Lauren stated, “I can see it coming into effect for someone who may not have the confidence or has never welded before [inaudible 00:24:01] to give them that confidence and get over the barrier that they might be scared of.” Tucker expressed, “I think that one good thing that the [VR welding system] brings to the table is the work angles and showing you what you're doing wrong and how you need to fix it with the little icons [visual cues].” Tucker also cautioned that using the VR welding system was not a suitable substitute for performing physical welds in the real world, stating, “If we want to really learn something, pull a piece of equipment in there [the teaching laboratory] and crawl underneath it and start burning some [welding] rods.” When discussing her approach to learning how to perform new welding positions, Lauren said, “It's, in my opinion, way different than being in an actual welding booth.” However, Lauren did offer compliments about the VR welding system, expressing that:

[The VR welding system] also gives you a good idea what it should look like to be a good weld. After you're done with your weld, you could look at what you did, and tells you exactly what parts of it may had a little bit of undercut or whatever, and you could see exactly what that would look like on your weld in real life.

The students in each focus group did, however, acknowledge that the VR welding system is not a perfect tool for teaching and learning, noting some technical limitations associated with the VR equipment itself and offering suggestions for continued improvement to integrating the VR welding system into the course. When discussing the GMAW process, Marie stated that:

With the MIG welding, you can't actually see the wire. In real welding you can see the wire and you can see how far it is, but you just have the circle [visual cue] and you can’t see the wire in the [VR welding system]. It makes it hard to find where you need to be.
Several students discussed limitations associated with the use of the welding helmet display. Kevin stated, “Honestly, I think it'd be better if they [the VR welding system manufacturer] had the ability to just put a small screen in front of you instead of those two little bifocals.”

The students also reported different ideas about how to further capitalize on using VR technology in the course. Wayne suggested that, “If it's going to be an introductory tool, then you should have everything lined up so you're doing this before you're going to the booth.” Kevin referenced this point as well and stated, “[M]aybe the first thing that should be [done] [is] define what your purpose is for this tool. Is this an introductory thing where you're going to use this for training purposes? 'Cause if it is, timing before the booth is everything.” Tucker said, “I think it should definitely be before you start [live] welding.” Jesse reported he liked the flexibility of the current student use structure, noting that, “I do like how it's set up now. You can go to it before or after you [live] weld.” Walter shared his own experiences with how he sequenced both VR welding and live welding, stating:

I did the [VR welding system] and then I got above the 80s or whatever just to get my scores. Then we went and actually did the weld and I could work through the real weld and figure out my technique and how I needed to do it. Perfect it a little bit better. Then, once I did that and I got my depth perception, I got all this, I got my angles, and everything. Once I went back to the [VR welding system], I got those scores up. I mean, my scores, they went up compared to where they were before we actually did the real welds.

Despite the limitations to its utility as a tool for teaching and learning, the students felt that having the VR welding system integrated into the course structure was an overall positive attribute and added a helpful dimension to weld process training.
Theme Three: Value Depends on the Individual

Throughout each focus group session, the students spent a portion of time detailing their perspectives on the value of the VR welding system for themselves and for others enrolled in the course. The thoughts shared by the students were focused on the notion that the value of the VR welding system depended upon the individual student and his or her prior experience with the welding processes taught in the course. Coulter felt that, “[I]f you're new to welding, I think it's a very useful piece [of equipment] because it teaches you work angles, how to calibrate your welder, and stuff like that.” Ryan shared his thoughts and stated, “I bet it [the VR welding system] does help people who haven't welded before. I bet it helps them get a little more comfortable just so they know what to do because you don't even know where to start.”

Lauren said that, “I personally [believe] [using the VR welding system] didn't benefit me as much. It probably might have benefited other people. It's just going to depend on your welder, depend on your person, too.” She went on to say, “The way I started welding may be a little different from others, but I can see where the [VR welding system] would definitely help give you that confidence to get into the booth for the first time.” Wayne supported this idea, stating that, “It depends what your background was before using the [VR welding system], in my opinion. If you've never welded before, I think it'd be great 'cause it shows you everything you need to do, how to do it.” Walter stated that:

I'd say it would be useful depending on the average of your majors. A lot of your ag[ricultural] kids are going to have experience or know how to weld somewhat. I know we have a few different majors in our class. I think in terms of that, yeah, it's very educational and useful because they get the experience, they get the hang of it, they see what it is… I mean, from that standpoint, I'd say it's useful.
Several students who had experience with welding prior to enrolling in the course felt that using the VR welding system hindered their performance when using actual welding equipment. Coulter opined that, “[I]f you know how to weld, I think it veers you off the wrong path on how to do it the right way with the real welder.” When probed for his thoughts on students with welding experience using the VR welding system in class, Wayne described that, “[I]f you've welded before you try to over-correct yourself too much trying to fix bad habits that you've got that work for you.” Lauren indicated she felt restricted by the VR welding system’s precision settings and tight weld parameter tolerances, noting that, “[S]ome people might find the [welding machine] settings that they like work best with just a slight difference in the angle or your work [travel] speed or your distance.”

Echoing the dialogue from other students in his focus group session, Ryan was assertive in his belief that, “[I]t [the VR welding system] probably has its place in the class, but I wouldn't ever base how [well] you can weld or what you should learn off of that.” Echoing Ryan, Jesse stated, “[T]here's kids [other course students] that probably don't have a whole lot of experience, so they can do better on the [VR welding system] than the real weld[ing] just because of their situation.” From the standpoint of a student who had substantial welding experience prior to enrolling in the course, Jesse went on to say, “The less I gotta mess with it [the VR welding system] the happier I am.”

Conclusions, Discussion, Recommendations, Implications, and Limitations

Students who participated in the two focus group sessions provided a great deal of insight into their perceived value of using the VR welding system as a teaching and learning tool. Students believed that there was some degree of alignment that existed between VR welding and live welding activities, that VR technology could serve as a tool for teaching and learning
purposes, and that the value of using VR technology was often dependent upon each student. These results coincided with Porter et al.’s (2005) findings that some VR technology users believe that a VR welding system can be suitable for training novices. These results also aligned with Yunus et al.’s (2011) findings that there exist some perceived benefits from using VR technology for welding skill development. As also reported by Fast et al. (2012), the results of the present study indicated that VR welding system users do not always have positive perspectives on using VR technology for welding skill development purposes.

From these students’ perspectives, it appeared that VR technology could serve practical roles in developing the welding-related psychomotor skills of students enrolled in university-level agricultural mechanics coursework, most notably when introducing students to new skills associated with course objectives. These findings indicate that simulator technologies can, from the student perspective, play a useful and pragmatic role in helping students, especially those who are inexperienced, to more fully grasp content taught within a university-level course. In alignment with the students’ suggestions, Whitney and Stephens (2014) noted that using simulator-based technologies such as VR for welding skill development may be more appropriate for novices than individuals with prior welding experience.

Students did not suggest that VR welding should ever replace physical, live welding; rather, they indicated using a VR technology application should be intended to help supplement the teaching and learning processes and provide experience in a safe, controlled virtual environment. This concept echoed the findings of Spicer and Stratford (2001) in their study of using VR technology for field trip activities in a university-level course. Students in their study expressed that VR technology usage was a practical way to introduce or re-visit a topic, but “that it could not, and should not, replace real field trips” (p. 345). Further, Tiffany and Hoglund
(2014) found that university-level students do perceive that challenges exist with implementing VR technology for intellectual development, especially when considering students’ adaptations to the technological aspects of the application and students’ self-efficacies, but that using VR technology as an assistive tool is still beneficial for students.

Students in the present study exhibited a wide range of ideas about using the VR welding system, expressing that while the behavior of using the VR technology in class was a mandatory exercise, some students were more hesitant about using it than others. It is conceivable that some students’ perspectives on using the technology may have been influenced by their peers’ actions, attitudes, and beliefs. Resistance to the VR welding system’s use was evident from some students; however, others indicated they were positive about using the system early into the course. Perhaps these intentions about performing the behavior in question were related to background factors that students brought into the course with them. Fishbein and Ajzen (2010) indicated that the process of behavioral follow-through can often be affected by such factors. Byrd (2014) and Stone et al. (2011) found that using VR technology can help to facilitate welding skill development. Student buy-in or lack thereof could impact the teaching and learning processes. This lack of buy-in could affect behaviors and course engagement over the long term. As indicated by McCubbins et al. (2016), student buy-in to instructional practices can help to better facilitate the knowledge and skill transfer process. Further investigation into these phenomena should be conducted.

Faculty who are considering adopting VR technology and implementing it into their coursework are advised to analyze their current instructional needs, course structures, and curricula to ensure that VR welding systems will adequately address students’ educational requirements and will complement the live weld process training procedures currently in place.
As simulator technologies are meant to enhance, not hinder, the learning experience, VR technology is designed to provide additional opportunities for student engagement and educational experiences (Youngblut, 1998). Moreover, simulator technologies can be used to help apply the experiential learning components described by Kolb (2015).

To help maximize the experiential learning process, faculty who are considering adopting and using VR technology should contemplate employing preflection and debriefing techniques before and after, respectively, using VR technology in their coursework. Preflection can be used to allow students to begin to engage cognitively, such as by establishing goals or anticipating an experience, in a topic or concept prior to actually experiencing it (Retallick, 2010). Debriefing can provide deep exploration of what was accomplished during virtual activities and how this new understanding can be applied elsewhere (Nicholson, 2012). These notions should be closely considered as technology adoption and implementation decisions are made at the local level.

As welding is a component of many agricultural mechanics courses offered in agricultural education settings (Burris et al., 2005; Pate, Warnick, & Meyers, 2012), skill acquisition is a top priority (Leiby, Robinson, & Key, 2013). Based on the findings from the present study, the authors recommend those who work with providing weld process training in contexts such as SBAE laboratories, post-secondary weld training programs, weld training courses at the secondary level, and university-level agricultural mechanics coursework consider all potential consequences of using VR technology as a method for providing psychomotor skill development in their respective settings. These consequences could include costs, students’ buy-in to using the technology, hardware and software update needs, and so forth.

While the present study examined the efficacy of a VR technology application from students’ perspectives, the authors recognize that perspectives can be altered based on experience
and that the results of the present study cannot be used to determine if using VR technology applications impacts psychomotor skill performance. Several of the students in the present study believed that using the VR technology application did help their understanding and performance of certain psychomotor skill aspects in some ways but that their live welding skill performance was or was not impacted by using VR.

The authors recognize that the results of the present study are not generalizable beyond the nine university-level agricultural mechanics course students who participated in these two focus groups during the Spring 2018 semester. The authors believe the students who participated in the present study provided valuable insight into the teaching and learning processes as related to integrating a VR technology application into a university-level agricultural mechanics course that includes a considerable amount of weld process training. Effective and skillful course instructors should be cognizant of students’ interests and engagement in the teaching and learning processes (Edgar et al., 2016; Lancelot, 1944; Phipps et al., 2008) and should consider the perspectives of students when making decisions about how to facilitate the educational experience (McCubbins et al., 2016).

References


CHAPTER 5. THE EFFECT OF VIRTUAL REALITY TECHNOLOGY ON WELDING SKILL PERFORMANCE

A paper prepared for submission to the Journal of Agricultural Education

Trent Wells and Greg Miller

Abstract

Simulator technologies, such as virtual reality (VR), can serve as practical tools in the educational process (Kneebone, 2005; Youngblut, 1998). VR technology applications can be effectively used for weld process training (Byrd, 2014). Weld process training can often be found in university-level agricultural education settings (Burris, Robinson, & Terry, 2005). We sought to determine if using a VR technology application within the context of a one-hour-long gas metal arc welding (GMAW) process training impacted welding skill performance as determined by certified welding inspectors (CWIs) who used a weld evaluation rubric based on American Welding Society (AWS) standards. One-hundred-and-one students from Iowa State University (ISU) participated in our study. Participants were randomly placed into one of four protocol groups: (1) 100% live welding, (2) 100% VR welding, (3) 50% live welding / 50% VR welding, or (4) 50% VR welding / 50% live welding. A one-way analysis of variance (ANOVA) indicated that there were no statistically significant differences ($p > .05$) in total weld scores between participants in the four training protocol groups. We recommended that this study be replicated.

Introduction

As one of many educational technologies that have emerged over prior decades (Saettler, 2004), simulator technologies for teaching and learning have been developed for and used in many contexts, including: (1) medicine (Cope & Fenton-Lee, 2008; Gallagher et al., 2003; Gor, McCloy, Stone, & Smith, 2003; Kilmon, Brown, Ghosh, & Mikitiuk, 2010; Kneebone, 2005; Seymour et al., 2002), (2) mine safety training (Filigenzi, Orr, & Ruff, 2000), (3) welding
(Abrams, Schow, & Riedel, 1974; Byrd, 2014; Byrd, Stone, Anderson, & Woltjer, 2015; Oz, Ayar, Serttas, Iyibilgin, Soy, & Cit, 2012; Stone, McLaurin, Zhong, & Watts, 2013; Stone, Watts, Zhong, & Wei, 2011; White, Prachyabrued, Chambers, Borst, & Reinders, 2011), (4) education (Agnew & Shinn, 1990; Nadolny, Woolfrey, Pierlott, & Kahn, 2013; Perritt, 1984), and (5) first responder training (Bliss, Tidwell, & Guest, 1997). Thiagarajan (1998) described a simulation as “a representation of the features and behaviors of one system through the use of another” (p. 35). As simulator technologies have become more widespread and will continue to evolve over time to fulfill different roles (Thiagarajan, 1998), their beneficence and effectiveness are expected to be quite high (Kneebone, 2005).

Using simulator technologies for teaching and learning purposes, such as training a welder how to perform a specific weld joint configuration, can potentially positively impact skill development (Nikolic, Radivojevic, Djordjevic, & Milutinovic, 2009; Scalese, Obeso, & Issenberg, 2008). Further, using simulator technologies as part of the teaching and learning processes can help to reduce anxiety when learning within a new skill domain (Byrd, 2014). Various technologies such as augmented reality (AR) (Lee, 2012; Yuen, Yaoyuneyong, & Johnson, 2011) and virtual reality (VR) (Youngblut, 1998) can be used to provide for a diversity of simulator technologies (Scalese et al., 2008). However, as Wenglinsky (1998) advised, the use of an educational technology alone does not necessarily result in increased achievement. Rather, using educational technology to facilitate teaching and learning, such as using a VR-based simulator technology to develop a skill set, should be done pragmatically and deliberately (Wenglinsky, 1998). As such, the selection and appropriate use of educational technology for a teaching and learning purpose should be conscientious.
The Virtual Reality Society (2017) described VR as “a three-dimensional, computer-generated environment which can be explored and interacted with by a person” (¶ 5). Pantelidis (1993) speculated that VR technology could have much potential to assist with teaching and learning procedures in the coming years. Helsel (1992) echoed this sentiment by stating that “[v]irtual reality holds much promise for education…[and] education has a tremendous wealth of information and experience to bring to the VR curriculum” (p. 42). Since Pantelidis’s (1993) and Helsel’s (1992) work, VR has continued to become further entrenched in educational settings. Bailenson (2018) postulated that as a result of rapid technological changes, VR technology holds much potential to continue impacting teaching and learning processes in the coming years.

Potkonjak et al. (2016) proposed that integrating VR technology into science-, technology-, and math-based content could serve as a practical educational intervention to help students acquire content-specific knowledge and skills more efficiently and effectively. Moreover, Byrd (2014) and Stone et al. (2011) indicated that using VR technology applications could be pragmatic and effective for developing welding-related psychomotor skills. As weld process training is often a foundational component of agricultural education programs at the university level (Burris, Robinson, & Terry, 2005), perhaps this approach could be beneficial for developing psychomotor skills in the context of weld process training in university-level agricultural education.

Psychomotor skills can be described as a linkage between various cognitive and physical processes that require physical motions and mental stimulation to successfully accomplish their objectives (Lancelot, 1944; Venes, 2017). Psychomotor skills could include such tasks as operating power machinery, performing open-heart surgery, or completing a hand-drawn sketch. Different career fields require individuals to make certain hand and body motions to perform
daily tasks. For example, in the context of medical science, psychomotor skills are particularly important for surgical practitioners, as fine movements must be made to ensure safe and effective surgical practice and the health of the patient (Gallagher et al., 2003; Kaufman, Wiegand, & Tunick, 1987). In welding, a career area traditionally within the scope of agricultural education (Burris et al., 2005; Pate, Warnick, & Meyers, 2012), individuals must use psychomotor skills to manipulate and maintain control over a molten weld puddle to complete various tasks (Bowditch, Bowditch, & Bowditch, 2017; Byrd, 2014).

In the application of psychomotor skills to a given setting, human-related factors such as prior experience and comfort, dexterity, and anxiety can influence performance (Byrd, 2014). Referencing the development of psychomotor skills within university-level agricultural education settings, Osborne (1986) noted that the psychomotor skill development process itself could be complex and challenging yet educationally rewarding. Wulf (2007) noted that developing motor skills for use in a certain context, such as the psychomotor skills used during welding activities, can take a considerable amount of time, effort, feedback, and continued practice to refine the appropriate skills. As noted by Bowditch et al. (2017), psychomotor skills used by welders can be quite varied, but typically are related to hand-eye coordination, hand and arm movements, and body positioning.

Using effective strategies to enhance the acquisition of abilities in a given subject area is of critical importance for continued success in the teaching and learning of skills and knowledge (Goldsmith, Stewart, & Ferguson, 2006). Phipps, Osborne, Dyer, and Ball (2008) noted that technology usage is often an important part of the teaching and learning processes in agricultural education settings. Moreover, psychomotor skill development is often an objective of many aspects of agricultural education (Lancelot, 1944; Osborne, 1986; Phipps et al., 2008).
Considering these concepts, perhaps using a VR technology application to develop psychomotor skills (e.g., weld process skills) in the context of a university-level agricultural education setting could yield practical results. Stone et al. (2011) indicated that individuals who used VR technology for welding skill development purposes performed comparably to, and in some cases superior to, individuals who underwent traditional weld training procedures. Thus, the potential advantages of using VR technology for weld training purposes becomes clearer.

Byrd (2014) suggested “that VR gives participants the capability to hone task-related abilities” (p. 63). Like Stone et al. (2011), Byrd (2014) used weld process training protocols that spanned several days, thus immersing his study’s participants in a somewhat lengthy duration of training exposure. To date, while several studies that have engaged participants over longer time frames have been conducted, limited data exist that describe the effects of short-duration training procedures on individuals’ welding skill performance. What effects would a VR technology training approach conducted over a short time span have on weld process skill performance?

**Theoretical Framework**

Skill acquisition theory (DeKeyser, 2015) underpinned our study. Skill acquisition theory describes the development of skills through three stages: “declarative, procedural, and automatic” (DeKeyser, 2015, p. 95). The first step in the skill acquisition process is the understanding of the skill itself and the procedures to be performed, otherwise referred to as declarative knowledge. Declarative knowledge can be obtained in several ways, including reading about a skill performance process, observing someone else perform the skill, watching a demonstration video, and so forth. Transforming declarative knowledge into procedural knowledge is the focus of the second step. During this step, which is often rapid in nature, the application of the basic knowledge and understanding about a concept begins via practice.
Practice usually lasts for an extended time and is focused on improving time to completion, accuracy, and gradually reducing the cognitive activity required to successfully complete the task.

Adequate practice is designed to help guide an individual to the third stage, automaticity (DeKeyser, 2015). As an individual continues to move toward automaticity, he or she is expected to continue improving until accuracy is high, task completion time is minimal in comparison to when the task was first being practiced, and the cognition needed for successfully addressing the skilled task has been minimized and is often inherent.

As focus is an important part of the skill acquisition process (Wulf, 2007), someone who is practicing a skill can alter his or her focus as automaticity is reached. For example, someone who is learning how to perform a 1G butt weld with the gas metal arc welding (GMAW) process while using a VR technology application may use visual cues provided on a heads-up display screen to help him or her understand how to properly apply travel angle theory to a virtual weld. While the skill is being understood and applied early in the practice process (i.e., entering from the declarative stage to the procedural stage), he or she may focus a great deal of time looking at the visual cue instead of the virtual weld. Over time, his or her focus point may change over to the virtual weld bead being produced instead of the visual cue, perhaps even removing the visual cue entirely once adequate practice with the skill has been completed and he or she moves into the automaticity stage. As noted by several scholars (DeKeyser, 2015; Lancelot, 1944; Osborne, 1986; Wulf, 2007), learning how to successfully acquire and apply skills is a time-consuming process that requires much physical and mental exertion to achieve success.

When examining the application of skill acquisition theory into our study, our primary focus was on welding skill application and performance in the context of a structured one-hour
GMAW process training session conducted by the lead researcher. We sought to apply the theoretical process of skill acquisition (DeKeyser, 2015) into each of the structured training protocols we used. Four different training protocols that each incorporated varying levels of VR technology application usage were applied in our study. We were able to conduct the training protocols with participants from different backgrounds and varying levels of prior experiences with the GMAW process. Through this approach, we were able to apply the different stages of skill acquisition (i.e., declarative, procedural, and automatic) into all four training protocols and work directly with participants during each stage.

The declarative stage occurred through the lead researcher’s verbal instruction and visual demonstration of the skill of focus, which was producing 2F tee joint welds using the GMAW process. Each participant then entered the procedural stage and was allowed solo, semi-supervised practice for a designated amount of time. The amount of time for practice varied based upon the training protocol that each participant was randomly assigned to. The objective of the practice session was to provide adequate time for basic skill conceptualization and application to occur and for procession into the automaticity stage to transpire. Afterward, a brief testing session occurred that allowed us to collect physical weld data for our study. As such, we used VR technology as an intervention technique within the skill acquisition process. Our principal interest was determining if using differing applications of a VR technology application for weld process training purposes had any impact on welding skill performance.

**Purpose**

The purpose of our study was to determine the effects of differing applications of VR technology usage on welding skill performance during a one-hour-long GMAW process training session. Our study aligned with the American Association for Agricultural Education (AAAE)
National Research Agenda (NRA) Research Priority Area 3: Sufficient Scientific and Professional Workforce That Addresses the Challenges of the 21st Century (Stripling & Ricketts, 2016). As the agricultural industry continues to change (Doerfert, 2011), a workforce suitable for addressing the challenges and needs of the future will be needed (Stripling & Ricketts, 2016). To help prepare future members of the agricultural industry workforce, such as school-based agricultural education (SBAE) teachers, effective and appropriate instructional practices should be used to ensure that adequate and useful skills, such as GMAW process theory and welding equipment use, are being developed and transferred. We postulated that technology-based applications may be capable of playing a pragmatic role in this process. Lindner, Rodriguez, Strong, Jones, and Layfield (2016) noted that technology is evolving and should be used to help solve problems facing agriculture currently and in the future. As Stone et al. (2011) indicated, using a VR technology application could be a practical method to help address workforce development needs.

**Research Hypothesis**

H1: Using VR technology to facilitate the development of welding skills to complete 2F tee joints will result in a significant impact on total weld scores.

**Methods and Procedures**

**Recruitment Procedures and Participant Information**

Our study was conducted during the Fall 2018 semester and consisted of undergraduate and graduate students enrolled at Iowa State University (ISU). After the ISU Institutional Review Board (IRB) approved our study, we invited all students majoring in Agricultural and Life Sciences Education (n = 186), Agricultural Studies (n = 338), Agricultural Education and Studies (n = 70), Agricultural Engineering (n = 229), Agricultural and Biosystems Engineering (n = 84),
Agricultural Systems Technology \((n = 170)\), Industrial Technology \((n = 290)\), and Mechanical Engineering \((n = 2,424)\) to participate via e-mail. We invited the students in these academic majors based on the lead researcher’s experiences with students’ interests in a welding-focused agricultural mechanics course taught by him. In addition to the e-mail sent to 3,791 students, the lead researcher used in-class announcements to recruit the 38 students who were enrolled in the two agricultural mechanics courses that he taught. The students in these two courses were part of the group of 3,791 ISU students who had been sent the invitational e-mail.

Within the invitational e-mail and the in-class announcements, students were asked to use a Doodle poll to select one participation time slot that best suited their personal schedules. To help incentivize students to participate, we offered a chance to win one of four $40.00 gift cards. Reminder e-mails and text messages were sent to students one day in advance of their scheduled participation time slot. Students were also invited to share information about the study with anyone they believed may be interested in participating regardless of their academic major.

Students were notified via the invitational e-mail and in-class announcements that they needed to wear clothing appropriate for welding activities.

We developed a paper-based questionnaire to collect participants’ demographics data. The questionnaire included eight questions related to participants’ gender, age, academic standing, academic major, prior welding experiences and welding simulator use, and daily video game playing time. We had three students in an undergraduate-level agricultural mechanics course evaluate the questionnaire to ensure that each item was worded clearly. They suggested a couple of minor question wording changes to improve clarity.

We added one question related to individuals’ dominant hand usage and three questions related to participants’ prior welding experiences to better understand how participants’ welding
experience may impact their welding skill performance. We had three other students in an undergraduate-level agricultural mechanics course evaluate the questionnaire to ensure that each item was worded clearly. They each reported that all the items on the questionnaire were worded clearly.

**Research Design**

Our study used a randomized posttest-only experimental research design (Campbell & Stanley, 1963; Figure 1). The posttest in our design was participants’ test welds.

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<th>Producing Horizontal 2F Tee Welds Using the GMAW Process</th>
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*Figure 1. Illustration of randomized posttest-only experimental design. R = random assignment; O = observation of test weld produced; X1 = 100% live welding; X2 = 100% VR welding; X3 = 50% live welding / 50% VR welding; X4 = 50% VR welding / 50% live welding*

Posttest-only designs are suitable for rigorous educational research and help to control for a wide range of threats to internal and external validity (Campbell & Stanley, 1963). Our use of random assignment, short duration training protocols, conducting one-on-one training with each participant, detailed scripts for each training protocol group, a valid and reliable weld evaluation rubric, and recruitment of all individuals from different majors controlled for this range of internal and external threats to validity.

As noted by Campbell and Stanley (1963), using a pretest can confound research results. Had we used a research design that incorporated a pretest of welding skill performance, pretest sensitization as a threat to internal validity and testing as a threat to external validity could have resulted. Our selection of a posttest-only design helped us to avoid these issues.
Instrumentation

Participants’ test welds were visually inspected and evaluated by American Welding Society (AWS)-credentialed CWIs. The CWIs used a weld evaluation rubric that was co-developed by the lead researcher and a CWI who did not evaluate welds for this study. The rubric was based on the AWS D1.1 Table 6.1 visual inspection criteria for statically-loaded connections and consisted of visual inspection criteria for weld cracks, the occurrence of porosity, completeness of fusion, both leg and throat fillet sizes, the presence of undercut, crater cross-section, and the weld profile. A maximum possible score of 100 points could be achieved using this rubric. The rubric is illustrated in Figure 2.

<table>
<thead>
<tr>
<th>Test ID:</th>
<th>Participant ID Code:</th>
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<tbody>
<tr>
<td>PERFORMANCE QUALIFICATION CHECKLIST: VISUAL INSPECTION RESULTS</td>
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<tr>
<td>AWS D1.1 TABLE 6.1 CRITERIA (STATICALLY-LOADED CONNECTIONS)</td>
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<tr>
<td>DIRECTIONS: Place a checkmark in the blank that best represents the weld’s characteristics.</td>
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<tr>
<td>Cracks:</td>
<td>Complete Fusion:</td>
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<tr>
<td>None Present</td>
<td>(20) Acceptable</td>
</tr>
<tr>
<td>Rejected</td>
<td>(0) Rejected</td>
</tr>
<tr>
<td>Weld Profile:</td>
<td>Undercut:</td>
</tr>
<tr>
<td>Meets Requirements</td>
<td>(10) None Present</td>
</tr>
<tr>
<td>Acceptable Below Tolerance</td>
<td>(7) Present Below Tolerance</td>
</tr>
<tr>
<td>Acceptable At Tolerance</td>
<td>(5) Present At Tolerance</td>
</tr>
<tr>
<td>Rejected / Exceeds Tolerance</td>
<td>(0) Present Above / Exceeds Tolerance</td>
</tr>
<tr>
<td>Fillet Size (Leg &amp; Throat):</td>
<td>Porosity:</td>
</tr>
<tr>
<td>Meets Requirements</td>
<td>(10) None Present</td>
</tr>
<tr>
<td>Acceptable Below Tolerance</td>
<td>(7) Present Below Tolerance</td>
</tr>
<tr>
<td>Acceptable At Tolerance</td>
<td>(5) Present At Tolerance</td>
</tr>
<tr>
<td>Rejected / Exceeds Tolerance</td>
<td>(0) Present Above / Exceeds Tolerance</td>
</tr>
<tr>
<td>Crater Cross-section:</td>
<td></td>
</tr>
<tr>
<td>Acceptable</td>
<td>(20)</td>
</tr>
<tr>
<td>Rejected</td>
<td>(0) Total Score:</td>
</tr>
</tbody>
</table>

Figure 2. Weld evaluation rubric.
After the rubric was developed, a panel of five experts was used to assess face validity and content validity. The five experts consisted of two agricultural teacher education faculty members who had taught school-based and university-level agricultural mechanics coursework that included welding for at least 10 years and three AWS-credentialed CWIs who had each been actively engaged in the welding industry in various capacities over the last decade. The rubric and a panel of experts guidelines form was submitted to each panel member for an initial review. During the review process, each panel member provided corrective feedback on both the rubric and the guidelines form. After all the panel members responded, the lead researcher made the recommended changes and re-submitted the rubric and the panel of experts guidelines form back to each panel member for a second review. During the second review, all five panel members agreed the rubric was face valid and content valid and was suitable for use in the study.

After the rubric was determined to be valid and suitable for use, we conducted a pilot study during the Summer 2018 semester. The pilot study consisted of 20 undergraduate and graduate students from ISU and was intended to help us identify and correct any issues associated with the study’s design and provide test weld data that could be used to determine the reliability of the rubric. We used Statistical Package for the Social Sciences (SPSS©) Version 24 software to help us randomly assign 40 different participation slots. While we originally planned to have 40 participants in the pilot study, only 20 students participated. The random assignment generated by using SPSS resulted in unequally-sized training protocol groups. Consequently, we opted to use another method during the formal study’s implementation in the Fall 2018 semester. The four protocol groups described in Figure 1 were used during the pilot study; participants in each group completed three test welds and chose one test weld to be evaluated by five CWIs in Iowa who volunteered to evaluate all 20 test welds from the pilot study.
Two of the five CWIs were community college-level welding program instructors while the other three CWIs were employed at a large commercial equipment manufacturing company. To determine the internal consistency of the rubric during the pilot study, we used only first-round data, which yielded a Cronbach’s alpha coefficient of .714 based on standardized items. Basing the Cronbach’s alpha coefficient on the standardization of items was used due to the application of differing rating levels used to evaluate welds. Cohen et al. (2011) noted that standardization allows for comparison between items that are comprised of different scales. Using the Cronbach’s alpha interpretations offered by George and Mallery (2003), we determined this rubric had an acceptable level of internal consistency.

We repeated these procedures with the data collected during the formal study conducted during the Fall 2018 semester. It should be noted that due to scheduling conflicts, only three CWIs who evaluated test welds during the pilot study were able to evaluate test welds during the formal study. During this second determination of internal consistency, the three CWIs evaluated all 101 test welds completed by the formal study participants. Data collected from the first-round evaluation yielded a Cronbach’s alpha coefficient of .860 based on standardized items and was also determined to be adequate using the standards set forth by George and Mallery (2003).

Following the test-re-test reliability method noted by Cohen, Manion, and Morrison (2011), the 20 test welds from the pilot study were twice evaluated independently by each of the five CWIs. The first and second evaluations were conducted at least one week apart. We used intraclass correlation coefficients (ICC) with 95% confidence intervals (CI) to determine both intra- and interrater reliability of each CWI who evaluated the test welds from the pilot and formal studies. ICCs can be used to determine the reliability of scales used in quantitative research designs (Fleiss & Cohen, 1973; Koo & Li, 2016). As noted by LeBreton and Senter
(2008), “[e]stimates of IRR [interrater reliability] are used to address whether judges rank order targets in a manner that is relatively consistent with other judges” (p. 816). In contrast, intrarater reliability “is estimated by having one rater score the same instrument on two different occasions” (Scholtes, Terwee, & Poolman, 2011, p. 237).

Five CWIs independently evaluated the 20 test welds produced during the pilot study on two separate occasions at least one week apart. Intrarater reliabilities were calculated using both the first and second rounds of data while the interrater reliability was determined by using only the first-round data. Intrarater reliabilities were as follows for CWIs one through five, respectively: .710, .951, .785, .827, and .814. Interrater reliability between all five CWIs was determined to be .926. Regarding interpretation, Koo and Li (2016) noted that, “ICC values less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability” (p. 158). These procedures were repeated with the test welds produced during the formal study. Intrarater reliabilities were as follows for CWIs one through three, respectively: .810, .670, and .819. Interrater reliability between all three CWIs was determined to be .863.

Procedures

All research activities took place at the ISU Agricultural Mechanics Teaching Laboratory. Prior to the implementation of the formal study, the lead researcher and another doctoral student who was not affiliated with our study created a chart to determine random assignment sequencing. Due to the lead researcher’s time constraints, we determined that the creation of 140 different hour-long participation time slots would be suitable for our research design. Four colored paper clips were drawn at random from a plastic cup 35 times to fill 140
participation time slots, thus ensuring that each color was drawn 35 times to help create four equally-sized protocol groups. The color of each paper clip corresponded to a designated group. Random assignment was based on order of appearance, thus eliminating random assignment sequencing errors if a student did not attend his or her designated participation time slot. For example, if seven students were scheduled to participate over the course of a given day and only three students participated, the random assignment designations were not impacted by the four students who did not participate as the group number corresponded to the order of appearance.

The formal study was conducted on Tuesdays, Thursdays, and Fridays over several weeks during the Fall 2018 semester. Each day, seven one-hour participation time slots were available with a 15-minute interval between each one. The 15-minute interval served as a time to reset welding equipment, clean the work stations, and prepare for the next participant. Upon arrival, participants were asked to complete a 12-item demographics questionnaire and were provided with welding personal protective equipment (PPE), which included welding gloves, a welding helmet, a welding jacket, ear plugs, and safety glasses. Individuals who did not wear clothing appropriate for welding activities were not allowed to participate in the study activities and were asked to re-schedule their participation on the Doodle poll.

Four different GMAW weld process training protocols were used. Each protocol lasted for approximately one hour. Protocol one was a 100% live welding approach and included 25 participants. Protocol two was a 100% VR welding approach and included 26 participants. Protocol three was a blended 50% live welding and 50% VR welding approach and included 25 participants. Protocol four was a blended 50% VR welding and 50% live welding approach and included 25 participants. Specific information about each training protocol is depicted in Table 1.
Table 1

*Weld Process Training Protocols*

<table>
<thead>
<tr>
<th>Protocol Number</th>
<th>Protocol Descriptor</th>
<th>Protocol Steps (Time Allowance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100% live welding</td>
<td>Informed consent letter reading and signing, demographics questionnaire completion (10 minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Researcher live weld demonstration (Five minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Participant live weld practice (30 minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Live test weld production and selection (Five minutes)</td>
</tr>
<tr>
<td>2</td>
<td>100% VR welding</td>
<td>Informed consent letter reading and signing, demographics questionnaire completion (10 minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Researcher virtual weld demonstration (Five minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Participant virtual weld practice (30 minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Researcher live weld demonstration (Five minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Live test weld production and selection (Five minutes)</td>
</tr>
<tr>
<td>3</td>
<td>50% live welding / 50% VR welding</td>
<td>Informed consent letter reading and signing, demographics questionnaire completion (10 minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Researcher live weld demonstration (Five minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Participant live weld practice (15 minutes)</td>
</tr>
<tr>
<td>Protocol Number</td>
<td>Protocol Descriptor</td>
<td>Protocol Steps (Time Allowance)</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Protocol Number</td>
<td>Protocol Descriptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protocol Steps (Time Allowance)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Researcher virtual weld demonstration (Five minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Participant virtual weld practice (15 minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Live test weld production and selection (Five minutes)</td>
</tr>
<tr>
<td>4</td>
<td>50% VR welding / 50% live welding</td>
<td>Informed consent letter reading and signing, demographics questionnaire completion (10 minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Researcher virtual weld demonstration (Five minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Participant virtual weld practice (15 minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Researcher live weld demonstration (Five minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Participant live weld practice (15 minutes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Live test weld production and selection (Five minutes)</td>
</tr>
</tbody>
</table>

The lead researcher used a detailed written script to guide each training protocol. When going through each protocol’s script, the lead researcher provided technical details about the procedures that each participant was expected to undergo and performed demonstrations of how to use the welding equipment to perform the 2F tee joint welds. Participants were provided with an unlimited supply of quarter-inch-thick mild steel plates to practice their welds and were allowed to ask the lead researcher questions when needed. Participants who underwent protocol groups one, three, and four used the same Miller® XMT® 350 CC/CV Multiprocess Welder to
practice their welds. Participants in protocol groups two, three, and four used the same Lincoln Electric® VRTEX® 360 to practice their virtual welds. Participants in these training protocol groups were not allowed to use the VR welding system’s visual cues function but were instead provided with system-scored visual post-weld feedback for different weld technique parameters (e.g., contact-to-work distance [CTWD], travel speed, work angle, etc.). These feedback data were displayed on a computer monitor attached to the system. It should be noted that due to a technical issue with the Lincoln Electric® VRTEX® 360 used in our study, participants in protocol groups two, three, and four were not able to hear any sounds associated with the VR welding process. We used a secure digital storage system to collect and save the virtual weld data produced by participants who underwent these three training protocols. The virtual weld data were not reported in this manuscript.

At the end of each training protocol, each participant was provided with six, quarter-inch-thick mild steel plates to produce three test welds using a Miller® XMT® 350 CC/CV Multiprocess Welder and subsequently selected the single best weld for evaluation by the CWIs. It should be noted that participants did not use the same Miller® XMT® 350 CC/CV Multiprocess Welder to perform both their practice welds and their three test welds but all participants did use the same Miller® XMT® 350 CC/CV Multiprocess Welder to produce their three test welds. Each participant’s self-selected best weld was cooled, marked with an identification code, and stored in a locked location accessible only by the lead researcher. The other two welds were placed into a designated location in the ISU Agricultural Mechanics Teaching Laboratory and were saved for metal recycling purposes. Upon the formal study’s conclusion, a debriefing e-mail was sent to all pilot and formal study participants that disclosed the study’s experimental design. After the formal study concluded, all 101 formal study participants’ test welds were independently
evaluated by three CWIs using the weld evaluation rubric previously described. When one week had passed, all 101 test welds were re-evaluated by the three CWIs. All evaluation data were compiled into an IBM SPSS Version 24.0 software data set and analyzed.

**Data Analysis**

To test our research hypothesis, we used a one-way analysis of variance (ANOVA) to compare the four weld process training protocol groups’ mean total weld scores. Our dependent variable was total weld score and our independent variable was the type of weld training protocol used. Prior to analyzing our data, we averaged the total weld scores from all three CWIs. We used Omega squared ($\omega^2$) to calculate effect size. ANOVA and Omega squared ($\omega^2$) are often used in tandem within quantitative agricultural education research (Kotrlik, Williams, & Jabor, 2011).

**Results**

One-hundred-and-one participants provided the data reported in this manuscript. Most of the participants were male ($f = 87; 86.1\%$). The average age of the participants was 22.05 years. The majority of the participants were right-hand dominant ($f = 88; 87.1\%$). Nearly one-third of the participants were seniors ($f = 32; 31.7\%$). Over half of the participants were majoring in Mechanical Engineering ($f = 54; 53.5\%$). On average, the participants spent 0.96 hours daily ($Mdn = 0.5, Md = 0.0, SD = 1.39$) playing video games. Specific details about the participants’ demographics are provided in Table 2.

Table 2

**Participant Demographics (n = 101)**

<table>
<thead>
<tr>
<th>Item</th>
<th>$f$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your gender?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>87</td>
<td>86.1</td>
</tr>
<tr>
<td>Female</td>
<td>14</td>
<td>13.9</td>
</tr>
</tbody>
</table>
Table 2 (continued)

<table>
<thead>
<tr>
<th>Item</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your age?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-21</td>
<td>64</td>
<td>63.4</td>
</tr>
<tr>
<td>22-25</td>
<td>25</td>
<td>24.8</td>
</tr>
<tr>
<td>26-29</td>
<td>5</td>
<td>5.0</td>
</tr>
<tr>
<td>30-33</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>34-37</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>38+</td>
<td>3</td>
<td>3.0</td>
</tr>
<tr>
<td>Which hand is your dominant hand?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left hand</td>
<td>13</td>
<td>12.9</td>
</tr>
<tr>
<td>Right hand</td>
<td>88</td>
<td>87.1</td>
</tr>
<tr>
<td>Please indicate your current academic standing.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman</td>
<td>16</td>
<td>15.8</td>
</tr>
<tr>
<td>Sophomore</td>
<td>14</td>
<td>13.9</td>
</tr>
<tr>
<td>Junior</td>
<td>24</td>
<td>23.8</td>
</tr>
<tr>
<td>Senior</td>
<td>32</td>
<td>31.7</td>
</tr>
<tr>
<td>Graduate</td>
<td>15</td>
<td>14.9</td>
</tr>
<tr>
<td>What is your academic major?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>54</td>
<td>53.5</td>
</tr>
<tr>
<td>Agricultural and Life Sciences Education</td>
<td>10</td>
<td>9.9</td>
</tr>
<tr>
<td>Industrial Technology</td>
<td>9</td>
<td>8.9</td>
</tr>
<tr>
<td>Agricultural Engineering</td>
<td>7</td>
<td>6.9</td>
</tr>
<tr>
<td>Agricultural Studies</td>
<td>7</td>
<td>6.9</td>
</tr>
<tr>
<td>Agricultural Education and Studies</td>
<td>4</td>
<td>4.0</td>
</tr>
<tr>
<td>Agricultural and Biosystems Engineering</td>
<td>4</td>
<td>4.0</td>
</tr>
<tr>
<td>Agricultural Systems Technology</td>
<td>3</td>
<td>3.0</td>
</tr>
<tr>
<td>Industrial and Agricultural Technology</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>Crop Production and Physiology</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>Aerospace Engineering</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>Estimate the average number of hours that you spend per day playing video (e.g., computer, console, mobile, etc.) games.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-1 hours</td>
<td>71</td>
<td>70.3</td>
</tr>
<tr>
<td>1-2 hours</td>
<td>17</td>
<td>16.8</td>
</tr>
<tr>
<td>2-3 hours</td>
<td>11</td>
<td>10.9</td>
</tr>
<tr>
<td>3+ hours</td>
<td>2</td>
<td>1.9</td>
</tr>
</tbody>
</table>

The participants’ welding experiences prior to engaging in our study are reported in Table 3. Most participants had not used a welding simulation / simulator system before (f = 79;
78.2%) and had welding experience prior to participating in our study ($f = 70; 69.3$%). Those who had welding experience prior to participating indicated they had learned to weld and had practiced their welding skills in a variety of settings. The participants had most frequently reported they had prior experience in the shielded metal arc welding (SMAW; $f = 58; 57.4$%) and the GMAW ($f = 60; 59.4$%) processes. On average, the participants reported they had the most hours of experience in the: (1) flux-cored arc welding process (79.29 hours), followed by the (2) GMAW process (67.52 hours), the (3) SMAW process (62.54 hours), the (4) gas tungsten arc welding (GTAW) process (35.18 hours), the (5) oxy-fuel welding (OFW) process (10.19 hours), and the (6) submerged arc welding (SAW) process (0.72 hours).

Table 3

_**Formal Study Participants’ Prior Welding Experiences (n = 101)**_

<table>
<thead>
<tr>
<th>Item</th>
<th>$f$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever used a welding simulation / simulator system (e.g., virtual reality, augmented reality, etc.) before?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>22</td>
<td>21.8</td>
</tr>
<tr>
<td>No</td>
<td>79</td>
<td>78.2</td>
</tr>
<tr>
<td>Have you ever welded before?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>70</td>
<td>69.3</td>
</tr>
<tr>
<td>No</td>
<td>31</td>
<td>30.7</td>
</tr>
<tr>
<td>If you have welded before, where have you learned how to weld?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At my family’s farm or business</td>
<td>24</td>
<td>23.8</td>
</tr>
<tr>
<td>At a farm or business not owned by my family</td>
<td>14</td>
<td>13.9</td>
</tr>
<tr>
<td>In a facility at my house (e.g., garage, workshop, etc.)</td>
<td>19</td>
<td>18.8</td>
</tr>
<tr>
<td>In my high school’s Agricultural Education program</td>
<td>13</td>
<td>12.9</td>
</tr>
<tr>
<td>In my high school’s Industrial Technology program</td>
<td>27</td>
<td>26.7</td>
</tr>
<tr>
<td>Other location</td>
<td>28</td>
<td>27.7</td>
</tr>
<tr>
<td>If you have welded before, where have you gotten the opportunity to weld or practice welding?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At my family’s farm or business</td>
<td>23</td>
<td>22.8</td>
</tr>
<tr>
<td>At a farm or business not owned by my family</td>
<td>18</td>
<td>17.8</td>
</tr>
<tr>
<td>In a facility at my house (e.g., garage, workshop, etc.)</td>
<td>21</td>
<td>20.8</td>
</tr>
</tbody>
</table>
Table 3 (continued)

<table>
<thead>
<tr>
<th>Item</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>In my high school’s Agricultural Education program</td>
<td>14</td>
<td>13.9</td>
</tr>
<tr>
<td>In my high school’s Industrial Technology program</td>
<td>26</td>
<td>25.7</td>
</tr>
<tr>
<td>Other location</td>
<td>23</td>
<td>22.8</td>
</tr>
</tbody>
</table>

If you have welded before, which of the following weld processes have you performed?

- Shielded metal arc welding (SMAW; “stick welding”) 58 57.4
- Gas metal arc welding (GMAW; “MIG”; “wire welding”) 60 59.4
- Flux-cored arc welding (FCAW) 14 13.9
- Submerged arc welding (SAW) 5 5.0
- Oxy-fuel welding (OFW) 23 22.8
- Gas tungsten arc welding (GTAW; “TIG”) 27 26.7

We assumed that because participants were randomly placed into one of the four protocol groups used in our study, any participants’ preexisting differences, such as prior welding experiences, familiarity using welding simulation / simulator systems, and so forth, would fall within the range of anticipated statistical variation and would not confound our results.

Table 4 reported descriptive statistics for each weld process training protocol group. The mean total weld score across all four protocol groups was 74.69 with a standard deviation of 17.61. The highest mean total weld score ($M = 80.15$, $SD = 15.07$) was from participants who underwent the 100% VR welding training protocol ($n = 26$) while the lowest mean total weld score ($M = 67.84$, $SD = 16.26$) was from participants who experienced the 50% live welding / 50% VR welding training protocol ($n = 25$).
Table 4

*Descriptive Statistics for Participants’ Total Weld Scores by Group*

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>SE</th>
<th>Min.</th>
<th>Max.</th>
<th>95% Confidence Interval for Mean</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% live welding</td>
<td>25</td>
<td>74.40</td>
<td>17.09</td>
<td>3.42</td>
<td>36.00</td>
<td>98.00</td>
<td>67.35 - 81.45</td>
<td>67.35</td>
<td>81.45</td>
</tr>
<tr>
<td>100% VR welding</td>
<td>26</td>
<td>80.15</td>
<td>15.07</td>
<td>2.96</td>
<td>39.00</td>
<td>98.00</td>
<td>74.07 - 86.24</td>
<td>74.07</td>
<td>86.24</td>
</tr>
<tr>
<td>50% live welding / 50% VR welding</td>
<td>25</td>
<td>67.84</td>
<td>16.26</td>
<td>3.25</td>
<td>28.00</td>
<td>100.00</td>
<td>61.13 - 74.55</td>
<td>61.13</td>
<td>74.55</td>
</tr>
<tr>
<td>50% VR welding / 50% live welding</td>
<td>25</td>
<td>76.16</td>
<td>20.40</td>
<td>4.08</td>
<td>31.00</td>
<td>99.00</td>
<td>67.74 - 84.58</td>
<td>67.74</td>
<td>84.58</td>
</tr>
<tr>
<td>Total</td>
<td>101</td>
<td>74.69</td>
<td>17.61</td>
<td>1.75</td>
<td>28.00</td>
<td>100.00</td>
<td>71.22 - 78.17</td>
<td>71.22</td>
<td>78.17</td>
</tr>
</tbody>
</table>

**Research Hypothesis:** Using VR Technology to Facilitate the Development of Welding Skills to Complete 2F Tee Joints Will Result in a Significant Impact on Total Weld Scores

A Levene’s test for homogeneity of variances indicated that the assumption of homogeneity was met ($p = .580$). Our use of a one-way ANOVA revealed that there were no statistically significant differences ($p > .05$) in total weld scores between any of the four training protocol groups, $F(3, 97) = 2.235, p = .089$. Effect size was calculated using Omega squared ($\omega^2 = 0.04$), which was classified as “very small” in accordance with the interpretations offered by Sawilowsky (2009, p. 599). Therefore, we rejected our research hypothesis (Table 5).

Table 5

*Comparative Analysis of Total Weld Scores by Group Means*

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
<th>$p$</th>
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</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>2005.381</td>
<td>3</td>
<td>668.460</td>
<td>2.235</td>
<td>.089</td>
</tr>
<tr>
<td>Within Groups</td>
<td>29006.105</td>
<td>97</td>
<td>299.032</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>31011.485</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. $\omega^2 = 0.04$*

**Conclusions, Discussion, Recommendations, and Implications**

Our results indicated that using VR technology within a one-hour-long GMAW process training session to facilitate development of welding skills to complete 2F tee joint welds did not
result in a statistically significant \( p > 0.05 \) impact on welding skill performance as determined by CWIs who used a weld evaluation rubric to determine total weld scores. As such, we concluded that using VR technology as part of this process neither improved upon nor detracted from participants’ total weld scores. The individuals who participated in the 100% VR welding group \((n = 26)\) had the highest mean total scores for their test welds \((M = 80.15, SD = 15.07)\). The individuals who participated in the 50% live welding / 50% VR welding group \((n = 25)\) had the lowest mean scores for their test welds \((M = 67.84, SD = 16.26)\). Perhaps the sequencing of the VR technology usage impacted performance. Researchers should examine sequencing of VR technology use in future studies. Determining a suitable time frame and method for introducing VR technology into the skill acquisition process could be impactful for skill training purposes.

We recommend that our study be replicated. We do wish to emphasize that both total participant quantities and group sizes should be increased to provide increased power for statistical testing. Perhaps even reducing the number of protocol groups used in future research to increase the size of each group could be beneficial. In terms of participant recruitment, the primary issue we experienced was that our research site was located off-campus and may not have been easily accessible for some prospective participants, thus reducing our total number of participants. In several instances, prospective participants contacted the lead researcher directly via e-mail or text message to notify him that the participant was unaware of the research site’s off-campus location and did not have suitable transportation there. Thus, we recommend that future studies be conducted at a central location that can be easily accessed by all prospective participants.

Considering the design of our study, we were left to question if our results would have been different had the participants undergone training protocols that spanned a longer time
frame. Scholars (DeKeyser, 2015; Lancelot, 1944; Osborne, 1986; Wulf, 2007) have previously noted that the development of skills can take a considerable amount of time to fully materialize. Byrd (2014) used weld training protocols that were at least one week in duration is his study. It is conceivable that had we extended the duration of our training protocols, we may have found significant differences in total weld scores between the protocol groups. However, it is also possible that increasing the length of time individuals were asked to participate to our study may have resulted in increased subject mortality, thus introducing an internal validity issue (Campbell & Stanley, 1963). We recommend that future researchers of welding skill performance carefully consider the durations of their studies and the effects of time on participants’ skill acquisition processes.

We elected to focus our study on welding skill performance in the context of GMAW process training. GMAW has fewer operator variables than other welding processes and can allow for quicker skill acquisition for novice welders (Rose, Pate, Lawver, Warnick, & Dai, 2015). Further, we selected 2F tee welds due to their simplicity in comparison to other weld configurations (Stone et al., 2013). In addition, participants who were assigned to the training protocols that used VR welding were not allowed to use visual cues as part of their practice sessions. Stone et al. (2013) noted that using visual cues can be useful in some instances and harmful in others. As such, we question if our results would have been different had we elected to implement a different welding process such as SMAW, selected a different weld configuration, or had allowed participants to use visual cues during VR welding practice. Further research focusing on each of these variables could provide useful information relevant to welding industry stakeholders.
Considering that the majority of our study’s participants \((n = 70; 69.3\%)\) reported that they had welding experience prior to participating in our study, we speculate that this may have been a factor contributing to our lack of identifying statistically significant results. To help to better control for this variable in future studies, we recommend that researchers consider conducting experimental or quasi-experimental research with groups of novices. Large groups of novices could be found in numerous settings, including SBAE programs or university-level agricultural mechanics coursework. Moreover, if conducted within the scope of a secondary- or university-level course, future studies could examine the impacts of using VR technology over a longer period of time, such as an entire semester or academic year, while helping to minimize participant attrition.

Regarding stakeholders, we recommend that professionals involved in welding education, such as agricultural education practitioners, continue to examine educational technology-based practices that can assist in the teaching and learning of psychomotor skills. Stone et al. (2011) indicated that using VR technology for weld process training purposes shows promise for preparing skilled welders. While our study did not indicate that VR technology made a statistically significant impact, follow-up research should be conducted to help determine if such technology should be considered as viable in the acquisition of welding-related psychomotor skills. Welding plays a considerable, traditional role in agricultural education, particularly at the secondary and university levels (Burris et al., 2005) and is included in many career areas in the agricultural industry. The agricultural industry is ever-changing (Doerfert, 2011) and must continue to critically examine the roles and impacts that new technologies and products adoption can play (Lindner et al., 2016).
References


CHAPTER 6. GENERAL CONCLUSIONS

General Conclusion, Discussion, and Recommendations

This dissertation features three journal articles that broadly assessed virtual reality (VR) technology in school-based and university-level agricultural education settings. Several overall conclusions can be drawn.

School-based agricultural education (SBAE) teachers in Iowa have mostly positive opinions about VR technology. Teachers also exhibit some uncertainty about VR technology in SBAE. Many teachers have had positive experiences using VR technology applications and believe that VR technology quality has improved over time. Most teachers indicate that they are receptive to incorporating VR technology in their programs in the future and that it is important for teachers to consider adding VR technology in their programs. Teachers believe that VR technology could be a practical method to help supplement current instructional practices but indicated that costs associated with VR technology are currently excessive. Most teachers believed that VR technology is appropriate for use in SBAE programs. Behaviors regarding a topic can be influenced by opinions. As such, understanding opinions can be useful in helping to determine possible pathways for VR technology in SBAE in the future.

Students in a university-level agricultural mechanics course indicate that using a VR welding system to develop welding-related psychomotor skills in a university-level agricultural mechanics course can be pragmatic. Students believe that VR technology usage may be more suited for individuals with limited welding experience versus more experienced welders. Students indicate that because limitations with using VR technology do exist, using a VR welding system should supplement and not replace experiences associated with using actual welding equipment to hone psychomotor skills. From a student perspective, using a VR welding
system in a university-level agricultural mechanics can serve practical purposes and can help to facilitate the teaching and learning of psychomotor skills. VR technology application use in university-level coursework should be purposeful in nature and should be aligned with course learning objectives. VR technology use behaviors and attitudes can be influenced by students’ perspectives. Understanding those perspectives can be useful for strategizing how to integrate VR technology in a way that enhances the teaching and learning experiences for course instructors and students alike.

The use of VR technology to provide gas metal arc welding (GMAW) process training in the context of an hour-long training session framed using skill acquisition theory did not significantly impact welding skill performance. VR technology use for welding skill development purposes must continue to be critically examined. Future research should examine the effects of variables such as weld process training protocol sequencing, length of training time, and participants’ prior welding experience on welding skill performance. Replication studies using novice welders should be conducted to better understand the impacts of VR technology usage on welding skill performance.

As a method of facilitating learning, VR technology applications show potential for inclusion in SBAE settings and in university-level agricultural mechanics coursework. In the context of measurable impacts of VR technology use on skill learning, caution should be taken when considering using VR technology for skill development in school-based and university-level agricultural education settings. The use of VR technology should be well-planned and designed to positively impact the teaching and learning experiences. VR technology may be more suited to introducing students to a topic and helping them to develop fundamental skills in a risk-free, virtual environment. The integration of VR technology into agricultural education
settings should be considered as a method to facilitate the teaching and learning processes, especially during weld process training. When viewed within the context of welding-related psychomotor skill development, VR technology can add value to the skill development process.

Based on the findings of this study, several questions about VR technology in agricultural education were raised and may be worth further exploration, including:

1. What barriers inhibit the adoption of VR technology for use in SBAE settings?
2. Could other technologies such as augmented reality (AR) and mixed reality (MR) serve as facilitation tools for teaching and learning processes in agricultural education?
3. What effects does the use of VR technology in a formal classroom setting over the duration of an entire course have on student performance and achievement?
4. If the experimental study was replicated with only participants with no prior welding experience, what impacts would this have on the results?
5. If the experimental study was re-designed as a quasi-experimental study conducted in a university-level agricultural mechanics course that provided instruction in weld processes, what impacts would such an approach have on students’ content knowledge and psychomotor skill acquisition?
6. If the experimental study was re-designed to focus on another welding process, such as shielded metal arc welding (SMAW), what impacts would this approach have on participants’ welding skill performance outcomes?
7. If the experimental study was re-designed to allow for weld process training protocols that were longer in duration (e.g., two hours, one week, etc.) instead of only one hour, what effects would such a modification have on participants’ welding skill performance outcomes?
APPENDIX A

IRB APPROVAL FORMS

This page contains details about an IRB approval for research involving in-service teachers' attitudes towards incorporating virtual reality technology into school-based agricultural education settings. The approval was dated 8/21/2017.

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where:
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- You do not need to submit an application for annual continuing review.
- You must carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. Only the IRB or designees may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.

Please be aware that approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required.
Date: 2/8/2018
To: Trent Wetts
223C Curtiss

From: Office for Responsible Research

Title: Post-secondary Students’ Perspectives on Using Virtual Reality Technology to Develop Psychomotor Skills in an Agricultural Mechanics Course

IRB ID: 18-012

Study Review Date: 2/8/2018

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

1. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
   - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
   - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- You do not need to submit an application for annual continuing review.
- You must carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. Only the IRB or designees may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.

Please be aware that approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted.
The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

2: Research involving use of educational tests (cognitive, diagnostic, aptitude, achievement, survey procedures, interview procedures, or observations of public behavior, unless (i) Information obtained is recorded in such a manner that human subjects can be identified, and (ii) Any disclosure of the human subjects’ responses outside the research could reasonably place the subject at risk of criminal or civil liability or be damaging to the subjects’ financial standing, employability, or reputation.

The determination of exemption means that:

- You do not need to submit an application for annual continuing review.
- You must carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. The purpose of review is to determine if the project still meets the federal criteria for exemption.
- In addition, changes to key personnel must receive prior approval.

Detailed information about requirements for submission of modifications can be found on our [website](#). For modifications that require prior approval, an amendment to the most recent IRB application must be submitted in IRBManager. A determination of exemption or approval from the IRB must be granted before implementing the proposed changes.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may
IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Date: 12/20/2017
To: Trent Wells
223C Curtiss

From: Office for Responsible Research

Title: Effects of Selected Training Protocols on Psychomotor Skill Performance: An Experimental Study in Agricultural Mechanics

IRB ID: 17-518

Approval Date: 12/19/2017
Date for Continuing Review: 12/19/2019
Submission Type: New
Review Type: Full Committee

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.

- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.

- Obtain IRB approval prior to implementing any changes to the study by submitting a Modification Form for Non-Exempt Research or Amendment for Personal Changes form, as necessary.

- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.

- Stop all research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Research activity can resume once IRB approval is reestablished.

- Complete a new continuing review form at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please be aware that IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. Approval from other entities may also be needed. For example, access to data from private records (e.g. student, medical or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. IRB approval in no way implies or guarantees that permission from these other entities will be granted.

Upon completion of the project, please submit a Project Closure Form to the Office for Responsible Research, 202 Kingland, to officially close the project.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.
The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.
- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.
- Obtain IRB approval prior to implementing any changes to the study.
- Inform the IRB if the Principal Investigator and/or Supervising Investigator end their role or involvement with the project with sufficient time to allow an alternate PI/Supervising Investigator to assume oversight responsibility. Projects must have an eligible PI to remain open.
- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.
- Stop all human subjects research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Human subjects research activity can resume once IRB approval is re-established.
- Submit an application for Continuing Review at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

IRB 03/2018
The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.

- **Retain signed informed consent documents** for 3 years after the close of the study, when documented consent is required.

- Obtain IRB approval prior to implementing any changes to the study.

- Inform the IRB if the Principal Investigator and/or Supervising Investigator end their role or involvement with the project with sufficient time to allow an alternate PI/Supervising Investigator to assume oversight responsibility. Projects must have an eligible PI to remain open.

- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others, and (2) any other unanticipated problems involving risks to subjects or others.

- Stop all human subjects research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Human subjects research activity can resume once IRB approval is re-established.

- Submit an application for Continuing Review at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.
Iowa State University

Institutional Review Board
Office for Responsible Research
Vice President for Research
2820 Lincoln Way, Suite 202
Ames, Iowa 50014
515-294-4566

Date: 10/15/2018
To: Kevin T Wells
From: Office for Responsible Research

Title: Effects of Selected Training Protocols on Psychomotor Skill Performance: An Experimental Study in Agricultural Mechanics

IRB ID: 17-518
Submission Type: Modification  Review Type: Expedited

Approval Date: 10/15/2018  Date for Continuing Review: 12/18/2019

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.

- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.

- Obtain IRB approval prior to implementing any changes to the study.

- Inform the IRB if the Principal Investigator and/or Supervising Investigator and their role or involvement with the project with sufficient time to allow an alternate PI/Supervising Investigator to assume oversight responsibility. Projects must have an eligible PI to remain open.

- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.

- Stop all human subjects research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Human subjects research activity can resume once IRB approval is re-established.

- Submit an application for Continuing Review at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

IRB 30/2018
APPENDIX B

DATA COLLECTION INSTRUMENTS, CONSENT DOCUMENTS, CORRESPONDENCE CONTACTS

PANEL OF EXPERTS GUIDELINES

ATTITUDES TOWARD THE USE OF VIRTUAL REALITY TECHNOLOGY IN SCHOOL-BASED AGRICULTURAL EDUCATION SETTINGS QUESTIONNAIRE

The objectives of this study are to:

1) Describe teachers’ attitudes toward the utility of virtual reality as a teaching technology to develop psychomotor skills.

2) Describe teachers’ attitudes toward the added value of using virtual reality technology in school-based settings.

3) Describe teachers’ attitudes toward the viability and sustainability of using virtual reality technology within school-based settings.

As you examine this questionnaire, please consider whether each item is:

1) Relevant to the objectives of the study

2) Clear and concise

3) Not “multi-barreled”

4) Free of technical jargon

- Please review each of the items in the questionnaire. Indicate if each item should be:

1) Retained as is (requires no mark)

2) Modified and retained (make edits / comments on the instrument)

3) Deleted (marked through)

Attitudes Toward the Use of Virtual Reality in School-based Agricultural Education Settings

Attitudes, as described by Ary, Jacobs, and Sorensen (2010), “may be defined as a positive or negative affect toward a particular group, institution, concept, or social object.” (p. 209). In the context of the use of virtual reality technology within educational settings, this could be further
distinguished as having positive or negative affects toward the use of such technologies within a classroom or laboratory environment. Because I am measuring attitudes through the use of a Likert scale in Part II of my questionnaire, I am seeking your assistance in evaluating the content, construct, and face validity of this section.

**Content Validity**

Please evaluate Part II of this questionnaire for content validity. Content validity, as detailed by Ary et al. (2010), is “the degree to which the items of a test representatively sample an intended content domain.” (p. 639). As such, after evaluating Part II of this questionnaire, please check one of the following responses regarding content validity.

________ The instrument is content valid.

________ The instrument will be content valid after making the recommended changes.

________ The instrument is not content valid for the following reasons:

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

**Construct Validity**

Please evaluate Part II of this questionnaire for construct validity. Construct validity, as explained by Ary et al. (2010), is simply “[t]he extent to which a test or other instrument measures what the researcher claims it does” (p. 638). As such, after evaluating Part II of this questionnaire, please check one of the following responses regarding construct validity.

________ The instrument is construct valid.

________ The instrument will be construct valid after making the recommended changes.

________ The instrument is not construct valid for the following reasons:

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

**Face Validity**

Please evaluate Part II of this questionnaire for face validity. Face validity, as expounded upon
by Ary et al. (2010), is “the extent to which examinees believe the instrument is measuring what it is supposed to measure.” (p. 228). As such, after evaluating Part II of this questionnaire, please check one of the following responses regarding face validity.

________ The instrument is face valid.

________ The instrument will be face valid after making the recommended changes.

________ The instrument is not face valid for the following reasons:

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
PANEL OF EXPERTS GUIDELINES

**Step One Directions:** After re-examining the scale used in Part I of my questionnaire, place an “X” in the box that marks whether the entire (Overall) scale, the Utility sub-scale, and the Added Value sub-scale are construct, content, and face validity.

<table>
<thead>
<tr>
<th>Construct Validity</th>
<th>Content Validity</th>
<th>Face Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Overall Scale (Questions 1-25)</td>
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<td></td>
</tr>
<tr>
<td>Utility Sub-scale (Questions 1-11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Added Value Sub-scale (Questions 12-25)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Step Two Directions:** If you checked “No” on any item above, please use the space below to describe what I would need to do to in order to make the item(s) fit into the “Yes” category.
First Contact: Pre-notice

Hello [NAME],

In a few days, you will receive an e-mail requesting that you complete a brief online questionnaire for an important research project currently being conducted at Iowa State University.

The purpose of this study is to better understand agricultural education teachers’ opinions about incorporating virtual reality technology into their coursework and/or teaching methods.

We are sending this e-mail in advance because we know that many people like to know ahead of time that they will be asked to participate in a survey. Thank you for your time and consideration. It is only with the generous help of people like you can that our research can be successful.

If you have any questions about this study, do not hesitate to contact us, Trent Wells, at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Regards,

Trent Wells  
Graduate Student  
Iowa State University

Greg Miller  
Professor  
Iowa State University
Cover Letter: Invitation to Serve as a Research Participant

Hello [NAME],

We are writing to request your participation in a study to examine inservice agricultural education teachers’ opinions about the use of virtual reality technology in school-based agricultural education.

You were selected to participate based upon your current status as a school-based agricultural education teacher in the state of Iowa. Your response is very important.

Your participation is voluntary, and you may withdraw your participation at any time without consequence. All responses will be kept secure and confidential. There are no foreseeable risks to participating in this study. You should be able to complete the questionnaire in approximately 20 minutes.

We hope that you will complete this questionnaire today. In order to access the questionnaire, enter the URL below into your Internet browser:

[URL]

If you have any questions about this study, do not hesitate to contact us, Trent Wells, at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Thank you very much for your participation.

Regards,

Trent Wells
Graduate Student
Iowa State University

Greg Miller
Professor
Iowa State University
First Reminder: Invitation to Serve as a Research Participant

Hello [NAME],

A few days ago, we sent you a letter requesting your participation in a study to examine inservice agricultural education teachers’ opinions about the use of virtual reality technology in school-based agricultural education.

If you have already completed the online questionnaire, please accept our sincerest thanks. If you have not already done so, please complete the questionnaire today. We are grateful for your help, as it is only through asking people such as yourself that we can better understand agricultural education teachers’ opinions about incorporating virtual reality technology into their coursework and/or teaching methods.

We hope that you will complete this questionnaire today. In order to access the questionnaire, enter the URL below into your Internet browser:

[URL]

If you have any questions about this study, do not hesitate to contact us, Trent Wells, at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Thank you very much for your participation.

Regards,

Trent Wells
Graduate Student
Iowa State University

Greg Miller
Professor
Iowa State University
Follow-up Contact - Second Reminder: Invitation to Serve as a Research Participant

Hello [NAME],

Several days ago, we sent you an e-mail with a link to an important questionnaire. The questionnaire aims to examine inservice agricultural education teachers’ opinions about the use of virtual reality technology in school-based agricultural education.

If you have already completed the online questionnaire, please accept our sincerest thanks. If you have not already done so, please complete the questionnaire today. We are grateful for your help, as it is only through asking people such as yourself that we can better understand agricultural education teachers’ opinions about incorporating virtual reality technology into their coursework and/or teaching methods.

We hope that you will complete this questionnaire today. In order to access the questionnaire, enter the URL below into your Internet browser:

[URL]

If you have any questions about this study, do not hesitate to contact us, Trent Wells, at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Thank you very much for your participation.

Regards,

Trent Wells
Graduate Student
Iowa State University

Greg Miller
Professor
Iowa State University
Hello [NAME],

We are writing to you regarding a very important study that will examine inservice agricultural education teachers’ opinions about the use of virtual reality technology in school-based agricultural education.

You were selected to participate based upon your current status as a school-based agricultural education teacher in the state of Iowa. Your response is very important.

Your participation is voluntary and you may withdraw your participation at any time without consequence. All responses will be kept secure and confidential. There are no foreseeable risks to participating in this study. You should be able to complete the questionnaire in approximately 20 minutes.

We originally sent you information regarding this study via e-mail, but we have yet to receive your response. Our prior e-mails may not have reached you, so we decided to send you this invitation by U.S. mail.

We hope that you will complete this questionnaire today. In order to access the questionnaire, enter the URL below into your Internet browser:

[URL]

If you have any questions about this study, do not hesitate to contact me, Trent Wells, at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Thank you very much for your participation.

Regards,

Trent Wells
Graduate Student
Iowa State University

Greg Miller
Professor
Iowa State University
**Virtual Reality:** Virtual reality is “an artificial environment which is experienced through sights and sounds provided by a computer and in which a person’s actions partly decide what happens in the environment” (Merriam-Webster, 2017).

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Unsure</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) I am familiar with the concept of virtual reality technology.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>2) I hold a positive opinion toward virtual reality technology.</td>
<td>☐</td>
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<tr>
<td>3) Virtual reality technology can be effectively used in agricultural education classroom settings.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>4) Virtual reality technology can be used effectively in agricultural education laboratory settings.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>5) Virtual reality technology is a useful method for psychomotor skill development.</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>6) Virtual reality technology is <strong>only</strong> useful for psychomotor skill development.</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>7) Virtual reality technology use will increase as a method of psychomotor skill development.</td>
<td>☐</td>
<td>☐</td>
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<td>8) Virtual reality technology is more of a gimmick or a game than an actual teaching tool.</td>
<td>☐</td>
<td>☐</td>
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<td>☐</td>
<td>☐</td>
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<tr>
<td>9) My students treat / would treat virtual reality training as a game or gimmick rather than as an actual teaching tool.</td>
<td>☐</td>
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<tr>
<td>10) I enjoy / would enjoy using virtual reality technology in my classroom.</td>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Unsure</td>
<td>Agree</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>11) My students enjoy / would enjoy using virtual reality technology in the classroom.</td>
<td></td>
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<tr>
<td>12) There is great value in trying to learn a new concept using virtual reality technology.</td>
<td></td>
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<tr>
<td>13) There is great value in trying to learn a new skill using virtual reality technology.</td>
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<td>14) I am comfortable trying to learn a new concept using virtual reality technology.</td>
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<td>15) I am comfortable trying to learn a new skill using virtual reality technology.</td>
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<tr>
<td>16) My students are / would be comfortable trying to learn a new concept using virtual reality technology.</td>
<td></td>
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<tr>
<td>17) My students are / would be comfortable trying to learn a new skill using virtual reality technology.</td>
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<td>18) Virtual reality technology is too costly to use in my classroom.</td>
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<td>19) The potential benefits to incorporating virtual reality technology into my classroom outweigh the potential costs of the technology.</td>
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<td>20) Virtual reality technology adds / could add value to my instructional approach.</td>
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<tr>
<td>Question</td>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Unsure</td>
<td>Agree</td>
<td>Strongly Agree</td>
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<td>21) Virtual reality technology would add more of a STEM focus to my program.</td>
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<td>22) My teaching methods / strategies would not benefit from the use of virtual reality technology.</td>
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<td>23) Virtual reality technology would increase my students’ interest in content at least some of the time.</td>
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<td>24) My administration would have a positive opinion toward the use of virtual reality technology in my program.</td>
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<td>25) My administration would support me in funding virtual reality technology for my program.</td>
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<td>26) How important is it for teachers to consider adding virtual reality technology as an instructional component within their agricultural education programs?</td>
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<td>________Not Important</td>
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<td>________Slightly Important</td>
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<td>________Moderately Important</td>
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<td>________Very Important</td>
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<td>27) How frequently do you incorporate new and emerging instructional technologies in your classroom?</td>
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<td>________Never</td>
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<td>________Rarely</td>
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<td>________Occasionally</td>
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<td>________Frequently</td>
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<td>________Very Frequently</td>
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<td>28) The quality of virtual reality technology has ________ over the last five years.</td>
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<td>________Declined</td>
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<tr>
<td>________Neither Declined nor Improved</td>
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<tr>
<td>________Improved</td>
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</tr>
</tbody>
</table>
29) I plan to implement virtual reality technologies within my classroom in the near future.

[ ] Definitely Not
[ ] Probably Not
[ ] Possibly
[ ] Probably
[ ] Definitely
OPINIONS ABOUT THE USE OF VIRTUAL REALITY TECHNOLOGY IN SCHOOL-BASED AGRICULTURAL EDUCATION SETTINGS QUESTIONNAIRE: PART II

1) Which of the following describes your prior experiences with virtual reality technology? (Check all that apply)

- [ ] No Prior Experiences
- [ ] Have Seen on the Internet
- [ ] Have Seen in Person
- [ ] Have Seen Another Person Use on the Internet
- [ ] Have Seen Another Person Use in Person
- [ ] Have Used It Myself

2) Which of the following best describes any experiences that you have had with using virtual reality technology?

- [ ] No Prior Experiences
- [ ] Very Negative
- [ ] Somewhat Negative
- [ ] Fairly Positive
- [ ] Very Positive

3) Please list any virtual reality technology that you have personally used outside of your classroom.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

4) Please list any virtual reality technology that you have used within your classroom.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
5) Please list any virtual reality technology that you would like to have regular access to for your classroom.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________
OPINIONS ABOUT THE USE OF VIRTUAL REALITY TECHNOLOGY IN SCHOOL-BASED AGRICULTURAL EDUCATION SETTINGS QUESTIONNAIRE: PART III

AGRICULTURAL EDUCATION TEACHER DEMOGRAPHICS

1) Including this academic year, how many years have you have been teaching?

_______ Years

2) Please indicate your highest degree earned (Check one):

_______ High School Diploma
_______ Associate’s
_______ Bachelor’s
_______ Master’s
_______ Education Specialist
_______ Doctorate

3) What is your age?

_______ Years

4) What is your gender?

___________________________________

5) What grade level(s) do you teach? (Check all that apply)

_______ Elementary School
_______ Middle School
_______ High School
_______ Community College
_______ Four-year College / University

6) What teaching endorsements do you currently hold?

______________________________________________________________________________

______________________________________________________________________________
OPINIONS ABOUT THE USE OF VIRTUAL REALITY TECHNOLOGY IN SCHOOL-BASED AGRICULTURAL EDUCATION SETTINGS QUESTIONNAIRE: PART IV

SCHOOL & AGRICULTURAL EDUCATION PROGRAM DEMOGRAPHICS

1) Approximately how many people live in the school district where your school is located?

_____ Less than 2,500
_____ At least 2,500 but no more than 50,000
_____ At least 50,000

2) What occupational cluster is your program based on?

___________________________________________________

3) What is your agricultural education program’s approximate total enrollment?

_____ Students

4) Including yourself, how many agricultural education teachers are in your school?

_____ Teachers

5) What type of facilities does your program have access to? (Check all that apply)

_____ Classroom Area
_____ Agricultural Mechanics Laboratory
_____ Greenhouse / Horticulture Laboratory
_____ Aquaculture / Aquaponics Laboratory
_____ Livestock Laboratory
_____ Land Laboratory
_____ Meats Laboratory
_____ Food Science Laboratory
_____ Computer Laboratory
_____ Other (Please describe): ____________________________________________

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE.
Subject: Invitation to Participate in a Virtual Reality Technology Focus Group Study

Hello [NAME],

You have received this message because you are a student enrolled in the Agricultural Mechanics Applications (AgEdS 388) course at Iowa State University this semester. I am requesting your participation in a research study about students’ perspectives on using virtual reality technology to develop welding skills in an agricultural mechanics course. This study is being conducted by me, Trent Wells, under the direction of my major professor, Greg Miller, and is required as part of my doctoral program in the Department of Agricultural Education and Studies.

For your part, you would be participating in a 90-minute-long focus group session. All focus group session activities will take place in Curtiss Hall. The session will be audio- and video-recorded, and either Skyler Rinker or Miranda Morris, both of whom are graduate students in the Department of Agricultural Education and Studies, will be taking observation notes, all as part of the research process. Please also note that there will be a follow-up focus group session later in the semester to ensure that your responses and ideas have been accurately represented.

Food and soft drinks will be provided during the focus group session.

If you wish to participate in this study, you will need to follow the Doodle poll link below and select several focus group session times that best fit your schedule. Please note that a focus group session time slot will be established based on the responses of the students. If you decide to participate, it is very important that you arrive on-time for the focus group session.

https://doodle.com/poll/t3kdv62r59pzr4y6

Please note that you must be 18 years of age or older to participate, that you are required to be enrolled in this semester’s AgEdS 388 course to participate, that your participation is voluntary, and you may withdraw your participation at any time without consequence. Participation in this study will have no impact on your grade in this course. All your data will be kept secure and confidential.

If you have any questions about this study, do not hesitate to contact Trent at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Thank you for your time and have a great day.

Regards,

Trent Wells
Graduate Student
Iowa State University

Greg Miller
Professor
Iowa State University
Subject: Reminder to Participate in a Virtual Reality Technology Focus Group Study Tomorrow (Room [NUMBER] in Curtiss Hall from [TIME] until [TIME])

Hello [NAME],

You have received this message because you are a student enrolled in the Agricultural Mechanics Applications (AgEdS 388) course at Iowa State University this semester and have previously indicated that you plan to participate in tomorrow’s focus group session. As a reminder, this study is being conducted by me, Trent Wells, under the direction of my major professor, Greg Miller, and is required as part of my doctoral program in the Department of Agricultural Education and Studies.

For your part, you will be participating in a 90-minute-long focus group session to be held tomorrow at [TIME]. All focus group session activities will take place in Room [NUMBER] in Curtiss Hall. The session will be audio- and video-recorded, and either Skyler Rinker or Miranda Morris, both of whom are graduate students in the Department of Agricultural Education and Studies, will be taking observation notes, all as part of the research process. Please also note that there will be a follow-up focus group session later in the semester to ensure that your responses and ideas have been accurately represented.

Pizza and soft drinks will be provided during the focus group session.

If you decide to participate, it is very important that you arrive on-time for the focus group session. The focus group session will begin promptly at [TIME] and is expected to last until [TIME].

Please note that you must be 18 years of age or older to participate, that you are required to be enrolled in this semester’s AgEdS 388 course to participate, that your participation is voluntary, and you may withdraw your participation at any time without consequence. Participation in this study will have no impact on your grade in this course. All of your data will be kept secure and confidential.

If you have any questions about this study, do not hesitate to contact Trent at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Thank you for your time, and have a great day.

Regards,

Trent Wells  
Graduate Student  
Iowa State University

Greg Miller  
Professor  
Iowa State University
In-class Announcement: Encouragement to Participate in a Virtual Reality Technology Focus Group Study

Hello students,

I have a brief announcement about a study that is about to start here at Iowa State University. It is about students’ perspectives on using virtual reality technology to develop welding skills in an agricultural mechanics course, and I am encouraging your participation in this research. This study is being conducted by Trent Wells, under the direction of his major professor, Greg Miller, and is required as part of his doctoral program in the Department of Agricultural Education and Studies.

For your part, you would be participating in a 90-minute-long focus group session. All focus group session activities will take place in Curtiss Hall. The session will be audio- and video-recorded, and either Skyler Rinker or Miranda Morris, both of whom are graduate students in the Department of Agricultural Education and Studies, will be taking observation notes, all as part of the research process. Please also note that there will be a follow-up focus group later in the semester to ensure that your responses and ideas have been accurately represented.

Pizza and soft drinks will be provided during the focus group session.

If you wish to participate in this study, you will need to follow the Doodle poll link in the e-mail that you recently received from Trent and select several focus group session times that best fit your schedule. Please note that a focus group time slot will be established based on the responses of the students. If you decide to participate, it is very important that you arrive on-time for the focus group session.

Please note that you must be 18 years of age or older to participate, that you are required to be enrolled in this semester’s AgEdS 388 course to participate, that your participation is voluntary, and you may withdraw your participation at any time without consequence. Participation in this study will have no impact on your grade in this course. All of your data will be kept secure and confidential.

If you have any questions about this study, do not hesitate to contact Trent at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Thank you for your time, and have a great day.
Subject: Invitation to Participate in a Virtual Reality Technology Focus Group Follow-up Session

Hello [NAME],

You have received this message because you previously participated in a research study about students’ perspectives on using virtual reality technology to develop welding skills in an agricultural mechanics course. This study is being conducted by me, Trent Wells, under the direction of my major professor, Greg Miller, and is required as part of my doctoral program in the Department of Agricultural Education and Studies.

For your part, you would be participating in a 30-minute-long follow-up focus group session. All follow-up focus group session activities will take place in Room [NUMBER] in Curtiss Hall. The purpose of the follow-up focus group session is to ensure that your responses and ideas previously collected during the first focus group session have been accurately represented.

If you wish to participate in this follow-up session, you will need to follow the Doodle poll link below and select several focus group session times that best fit your schedule. Please note that a focus group session time slot will be established based on the responses of the students. If you decide to participate, it is very important that you arrive on-time for the focus group session.

https://doodle.com/poll/u5d4vd8ggwgfzp59

Please note that you must be 18 years of age or older to participate, that you are required to be enrolled in this semester’s AgEdS 388 course to participate, that your participation is voluntary, and you may withdraw your participation at any time without consequence. Participation in this study will have no impact on your grade in this course. All of your data will be kept secure and confidential.

If you have any questions about this study, do not hesitate to contact Trent at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Thank you for your time, and have a great day.

Regards,

Trent Wells
Graduate Student
Iowa State University

Greg Miller
Professor
Iowa State University
Subject: Reminder to Participate in a Virtual Reality Technology Focus Group Follow-up Session Tomorrow (Room [NUMBER] in Curtiss Hall from [TIME] until [TIME])

Hello [NAME],

You have received this message because you previously participated in a research study about students’ perspectives on using virtual reality technology to develop welding skills in an agricultural mechanics course. This study is being conducted by me, Trent Wells, under the direction of my major professor, Greg Miller, and is required as part of my doctoral program in the Department of Agricultural Education and Studies.

For your part, you would be participating in a 30-minute-long follow-up focus group session to be held tomorrow at [TIME]. All follow-up focus group session activities will take place in Room [NUMBER] in Curtiss Hall. The purpose of the follow-up focus group session is to ensure that your responses and ideas previously collected during the first focus group session have been accurately represented.

If you decide to participate, it is very important that you arrive on-time for the follow-up focus group session. The focus group session will begin promptly at [TIME] and is expected to last until [TIME].

Please note that you must be 18 years of age or older to participate, that you are required to be enrolled in this semester’s AgEdS 388 course to participate, that your participation is voluntary, and you may withdraw your participation at any time without consequence. Participation in this study will have no impact on your grade in this course. All of your data will be kept secure and confidential.

If you have any questions about this study, do not hesitate to contact Trent at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Thank you for your time, and have a great day.

Regards,

Trent Wells                     Greg Miller
Graduate Student                Professor
Iowa State University           Iowa State University
INFORMED CONSENT DOCUMENT

Title of Study: Virtual Reality Technology Focus Group Study

Investigators: Trent Wells, principal investigator (PI)/graduate student, Greg Miller, professor/faculty supervisor, Skyler Rinker, graduate student, and Miranda Morris, graduate student

This form describes a research project. It has information to help you decide whether or not you wish to participate. Research studies include only people who choose to take part—your participation is completely voluntary. Please discuss any questions you have about the study or about this form with the project staff before deciding to participate.

Introduction

The purpose of this study is to better understand students’ perspectives on using virtual reality technology to develop welding skills in an agricultural mechanics course. All students enrolled in this semester’s Agricultural Mechanics Applications (AgEdS 388) course have been invited to participate.

You should not participate if you are under 18 years of age and/or not enrolled in this semester’s AgEdS 388 course.

Description of Procedures

If you agree to participate, you will:

- Be asked to participate in a focus group session. This session should last approximately 90 minutes. Your responses will be assigned a pseudonym on the transcripts of the focus group session; thus, your name will not appear on any transcripts or within any publications that result from this study. The focus group session will take place in Curtiss Hall and will be audio- and video-recorded. Skyler Rinker or Miranda Morris, both of whom are graduate students in the Department of Agricultural Education and Studies, will also be taking observation notes.
- Be asked to participate in a follow-up focus group session later in the semester to ensure that your responses and ideas collected during the first focus group session have been accurately represented. This session should last approximately 30 minutes.

Risks or Discomforts

There are no anticipated risks and/or discomforts as a result of your participation in this study. You may withdraw from this study at any time without penalty. Your name will not be on the transcripts of the focus group session. Any collected data will only be seen by the study’s investigators.

Benefits

There are no direct benefits to you as a result of participating in this study. It is hoped that the
information gained in this study will benefit society by better understanding students’ perspectives on using virtual reality technology to develop welding skills in an agricultural mechanics course.

**Costs and Compensation**

You will not have any costs from participating in this study. You will be provided with free food and soft drinks during the focus group study.

**Participant Rights**

Participating in this study is completely voluntary. You may choose not to take part in the study or to stop participating at any time, for any reason, without penalty or negative consequences. Your choice of whether or not to participate will have no impact on you as a student or employee in any way.

If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115.

**Research Injury**

Emergency treatment of any injuries that may occur as a direct result of participation in this research is available at the Iowa State University Thomas B. Thielen Student Health Center and/or referred to Mary Greeley Medical Center or another physician or medical facility at the location of the research activity. Compensation for any injuries will be paid if it is determined under the Iowa Tort Claims Act, Chapter 669 Iowa Code. Claims for compensation should be submitted on approved forms to the State Appeals Board and are available from the Iowa State University Office of Risk Management and Insurance.

**Confidentiality**

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies, auditing departments of Iowa State University, and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy study records for quality assurance and data analysis. These records may contain private information. Any transcripts will be stripped of personal information that is linked to you before analysis. Information in any publication will not identify anyone.

To ensure confidentiality to the extent permitted by law, the following measures will be taken:

- Pseudonyms will be assigned in place of participants’ names.
- Any and all physical data will be stored in a locked filing cabinet in the PI’s office.
- Any and all electronic data will be stored in a secure, password-protected Cybox folder that is accessible only by the study’s investigators.
• Any and all audio- and video-recorded data will be accessible only by the study’s investigators and will be destroyed at the conclusion of the study.
• No identifiable data will be reported in any publications or presentations that result from this research study.
• Only the study’s investigators will have access to any data collected within this research study.

Questions

You are encouraged to ask questions at any time during this study. For further information about the study, contact Trent Wells, at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Consent and Authorization Provisions

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant’s Name (printed)  

Participant’s Signature  Date
Focus Group Interview Guide
AgEdS 388 Students

1. Opening

What do you enjoy about the AgEdS 388 course?

2. Transition Questions

Who enjoys the welding portion of the course?

What do you like about the welding portion?

What about the virtual reality welding simulator? How’s that going?

3. Key Questions

What value do you perceive in using the VR weld training system as part of the course’s weld training protocol?

What barriers, from a student perspective, exist to effectively using the VR weld training system as part of the course’s weld training protocol?

What benefits, from a student perspective, exist to using the VR weld training system as part of the course’s weld training protocol?

In future semesters of the AgEdS 388 course, what could be done to improve the experience of using the VR weld training system as part of the course’s weld training protocol?

4. Additional / Potential Questions

What did you like about using the virtual reality welding simulator to help you with your welding skills?

What did you dislike about using the virtual reality welding simulator to help you with your welding skills?

How did using the virtual reality welding simulator help you to become a better welder? Please explain.

How do you think that a sequence of live welding then using the virtual reality welding simulator could affect your welding skills?

What was user-friendly about the virtual reality welding simulator?

What was not user-friendly about the virtual reality welding simulator?
Explain how you think using the virtual reality welding simulator was compatible with live weld process training.

5. Probes / Facilitation Remarks

Probe: Can you give me an example of what you mean by [?]

Probe: Could you please tell me more about [?]

Probe: I’m not quite sure I understood [?]. Could you please tell me about that some more?

Probe: I’m not certain what you mean by [?]. Could you give me some more examples?

Probe: Could you tell me more about your thinking on that?

Probe: You mentioned [?]. Could you tell me more about that? What stands out in your mind about that?

Probe: This is what I thought I heard [?]. Did I understand you correctly?

Probe: So what I hear you saying is “[?]”.

Probe: Can you give me an example of [?]

Probe: What makes you feel that way?

Probe: What are some of your reasons for liking it?

Probe: What are some of your reasons for disliking it?

Probe: You just told me about [?] I’d also like to know more about [?].

Facilitation: I am going to invite people who have not had a chance to speak [as much] to start the conversation.

6. Ending Questions / Closing Remarks
So the main issues seem to be: [list].

And the main benefits seem to be: [list].

I also hear: [minority issues].

Is there something I have not heard as clearly that someone will say now?

All things considered, I think that we had an excellent discussion. Thank you very much for taking time out of your day to give us your thoughts. Later on in the semester, there will be a follow-up focus group interview session that will be much shorter than this one, and we want you to be a part of it, too. The purpose of this follow-up is to make sure that we accurately interpret what you have said today.
WELD EVALUATION RUBRIC

I am trying to create a way to measure the quality of 2F position horizontal tee joint test welds. The characteristics in the attached rubric come from the American Welding Society standards in D1.1, Table 6.1. I have attached the table for your reference. I am seeking your assistance in assuring that this is a proper and correct set of characteristics, and that the point values used to score the weld criteria are correct in representing their relative importance.

- Please review each of the weld characteristics in this rubric. Indicate if each item should be:
  1) Retained as is (requires no mark)
  2) Modified and retained (make edits / comments on the rubric)
  3) Deleted (marked through)

Are the weld characteristics in this rubric correct and appropriate measures of weld quality? After evaluating this rubric, please check one of the following responses.

________ The weld characteristics in this rubric are correct and appropriate measures of weld quality.

________ The weld characteristics in this rubric will be correct and appropriate measures of weld quality after making the recommended changes.

________ The weld characteristics in this rubric are not correct and appropriate measures of weld quality for the following reasons:

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Are the point values used in the scoring of the weld criteria correct in representing their relative importance? After evaluating this rubric, please check one of the following responses.

________ The point values used in the scoring of the weld criteria are correct in representing their relative importance.
The point values used in the scoring of the weld criteria will be correct in representing their relative importance after making the recommended changes. 

The point values used in the scoring of the weld criteria are not correct in representing their relative importance for the following reasons:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Do you believe this rubric looks like a measure of weld quality? After evaluating this rubric, please check one of the following responses.

The rubric looks like a measure of weld quality.

The rubric will look like a measure of weld quality after making the recommended changes.

The rubric does not looks like a measure of weld quality for the following reasons:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Subject: Invitation to Participate in a Welding Skill Performance Pilot Study

Hello [NAME],

You have received this message because you are a student enrolled in the [PROGRAM NAME] in the Department of [DEPARTMENT NAME]. I am requesting your participation in a pilot study about welding skill performance. This study is being conducted by me, Trent Wells, under the direction of my major professor, Greg Miller, and is required as part of my doctoral program in the Department of Agricultural Education and Studies.

For your part, you would be completing a short demographics questionnaire and participating in a 60-minute-long welding instruction, practice, and testing session. All welding activities will take place at the ISU Agricultural Mechanics Teaching Laboratory, which is located at 52097 260th Street, Ames, Iowa 50011.

Participation in the designated activities within the study will entitle you to be entered into a drawing to win a $40.00 gift card.

If you wish to participate in this study, you will need to follow the Doodle poll link below and select an appointment time that best fits your schedule. Please note that a particular time slot is no longer available if it has already been selected by another individual. If you decide to participate, it is very important that you arrive on-time for your scheduled appointment.

[URL]

Please note that you must be 18 years of age or older to participate, that you should not participate if you have a history of seizures or seizure disorders, that your participation is voluntary, and you may withdraw your participation at any time without consequence. All of your data will be kept secure and confidential. Because there exists a risk of minor injuries during the welding process, appropriate safety equipment and training will be provided. You will, however, need to wear long pants without any holes and/or frays (i.e., jeans or work pants) and close-toed leather shoes (work boots preferred) to your appointment.

If you have any questions about this study, do not hesitate to contact us, Trent Wells, at (205) 471-1303 or kw0004@iastate.edu, or Greg Miller, at (515) 294-2383 or gsmiller@iastate.edu.

Regards,

Trent Wells  
Graduate Student  
Iowa State University

Greg Miller  
Professor  
Iowa State University
In-class Announcement: Encouragement to Participate in a Welding Skill Performance Pilot Study

Hello students,

I have a brief announcement about a pilot study that is about to start here at Iowa State University. It is about welding skill performance, and I am encouraging your participation in this research. This pilot study is being conducted by Trent Wells, under the direction of his major professor, Greg Miller, and is required as part of his doctoral program in the Department of Agricultural Education and Studies.

For your part, you would be completing a short demographics questionnaire and participating in a 60-minute-long welding instruction, practice, and testing session. All welding activities will take place here at the ISU Agricultural Mechanics Teaching Laboratory.

Participation in the pilot study will entitle you to be entered into a drawing to win a $40.00 gift card.

If you wish to participate in this pilot study, you will need to follow the Doodle poll link in the e-mail that you recently received from Trent and select an appointment time that best fits your schedule. Please note that a particular time slot is no longer available if it has already been selected by another individual. If you decide to participate, it is very important that you arrive on-time for your scheduled appointment.

Please note that you must be 18 years of age or older to participate, that you should not participate if you have a history of seizures or seizure disorders, that your participation is voluntary, and you may withdraw your participation at any time without consequence. Participation in this study will have no impact on your grade in this course. All of your data will be kept secure and confidential. Because there exists a risk of minor injuries during the welding process, appropriate safety equipment and training will be provided. You will, however, need to wear long pants without any holes or frays (i.e., jeans or work pants) and close-toed leather shoes (work boots preferred) to your appointment. Please invite anyone who you believe may be interested in this study to participate.

If you have any questions about this study, do not hesitate to contact Trent at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Thank you for your time, and have a great day.
INFORMED CONSENT DOCUMENT

Title of Study: Welding Skill Performance Pilot Study

Investigators: Trent Wells, primary investigator (PI), graduate student, and Greg Miller, professor/faculty supervisor

This form describes a research project. It has information to help you decide whether or not you wish to participate. Research studies include only people who choose to take part—your participation is completely voluntary. Please discuss any questions you have about the study or about this form with the project staff before deciding to participate.

Introduction

The purpose of this study is to better understand how welding skills can be developed.

You have been invited to participate in this study. You should not participate if you are under 18 years of age and/or have a history of experiencing seizures or seizure disorders.

Description of Procedures

If you agree to participate, you will:

- Be asked to complete a short demographics questionnaire. This should take approximately 10 minutes.
- Be provided with safety gear, given instruction on how to use welding equipment, asked to use the welding equipment to practice welding, and asked to produce a test weld for evaluation by a certified welding inspector (CWI) who is not affiliated with Iowa State University. After equipment use instruction has been given, you will be given time to practice using the welding equipment prior to producing the test weld. The test weld will be done with a different welding machine than the one that you used to practice welding. This phase of the study should take approximately 40 to 50 minutes.

Risks or Discomforts

While participating in this study you may experience the following risks or discomforts:

- Minor burns from hot metal and/or sparks
- Noise from the welding process
- Bright light given off by the weld arc
- Heat from hot metal

To minimize these risks, you will wear jean/work pants without any holes and/or frays and close-toed leather shoes/boots to the research sites and use the provided personal protective equipment (PPE) while at the research site. The provided PPE will include safety glasses, ear plugs, flame-resistant welding gloves, a flame-resistant welding jacket, a welding cap, and a welding helmet/hood. You should not participate if you have a history of seizures or seizure disorders.
Benefits
If you decide to participate in this study, there may be direct benefits to you in the form of receiving free welding skill training. It is hoped that the information gained in this study will benefit society by better understanding how welding skills can be developed.

Costs and Compensation
You will not have any costs from participating in this study. You may possibly be compensated for participating in this study. Your name could be randomly drawn to win a $40.00 gift card. This drawing will occur at the conclusion of the study, and you will be notified via e-mail if your name was selected. You will need to complete a form to receive payment. Please know that payments may be subject to tax withholding requirements, which vary depending upon whether you are a legal resident of the U.S. or another country. If required, taxes will be withheld from the payment you receive.

Participant Rights
Participating in this study is completely voluntary. You may choose not to take part in the study or to stop participating at any time, for any reason, without penalty or negative consequences. Your choice of whether or not to participate will have no impact on you as a student or employee in any way.

If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115.

Research Injury
Emergency treatment of any injuries that may occur as a direct result of participation in this research is available at the Iowa State University Thomas B. Thielman Student Health Center and/or referred to Mary Greeley Medical Center or another physician or medical facility at the location of the research activity. Compensation for any injuries will be paid if it is determined under the Iowa Tort Claims Act, Chapter 669 Iowa Code. Claims for compensation should be submitted on approved forms to the State Appeals Board and are available from the Iowa State University Office of Risk Management and Insurance.

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To ensure confidentiality to the extent permitted by law, the following measures will be taken:

- All research activities will be completed by the participants on an individual basis.
- All test welds will be coded to protect the identities of the participants.
• All test welds will be stored in a locked, secure location at the research site.
• All questionnaires will be stored in a locked filing cabinet in the PI’s office.
• All electronic data will be stored in a secure, password-protected Cybox folder that is accessible only by the PI and the faculty supervisor.
• No identifiable data will be reported in any publications or presentations that result from this research study.
• Only the PI and the faculty supervisor will have access to any data collected within this research study.
• Any de-identified welding skill performance data may be retained and used for future research purposes.

Questions
You are encouraged to ask questions at any time during this study. For further information about the study, contact Trent Wells, at (205) 471-1303 or kw0004@iastate.ech, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Consent and Authorization Provisions
Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant’s Name (printed) __________________________________________

Participant’s Signature __________________________________ Date ___________
Participant ID Code: ________________________________

WELDING SKILL PERFORMANCE STUDY

PARTICIPANT DEMOGRAPHICS QUESTIONNAIRE

1) What is your gender?

____________________________________

2) What is your age?

______ Years

3) Please indicate your current academic standing (Check one):

______ Freshman
______ Sophomore
______ Junior
______ Senior
______ Graduate

4) What is your academic major?

____________________________________

5) Have you ever welded before?

______ Yes
______ No

6) If you have welded before, which of the following processes have you done?

______ Shielded Metal Arc Welding (SMAW; “Stick Welding”)
______ Gas Metal Arc Welding (GMAW; “MIG”; “Wire Welding”)
______ Flux Cored Arc Welding (FCAW)
______ Submerged Arc Welding (SAW)
______ Oxy-fuel Welding (OAW)
______ Gas Tungsten Arc Welding (GTAW; “TIG”)

7) Have you ever used a welding simulation system before?

______ Yes
______ No

8) Estimate the number of hours that you spend per day playing video (e.g., computer, console, mobile, etc.) games.

______ Hour(s) per day
Subject: Invitation to Participate in a Welding Skill Performance Study

Hello [NAME],

You have received this message because you are a student enrolled in the [PROGRAM NAME] in the Department of [DEPARTMENT NAME]. I am requesting your participation in a research study about welding skill performance. This study is being conducted by me, Trent Wells, under the direction of my major professor, Greg Miller, and is required as part of my doctoral program in the Department of Agricultural Education and Studies.

For your part, you would be completing a short demographics questionnaire and participating in a 60-minute-long welding instruction, practice, and testing session. All welding activities will take place at the ISU Agricultural Mechanics Teaching Laboratory, which is located at:

52097 260th Street, Ames, Iowa 50011

Participation in the designated activities within the study will entitle you to be entered into a drawing to win one of four $40.00 gift cards.

If you wish to participate in this study, you will need to follow the Doodle poll link below and select an appointment time that best fits your schedule. Please note that a particular time slot is no longer available if it has already been selected by another individual. If you decide to participate, it is very important that you arrive on-time for your scheduled appointment.

https://doodle.com/poll/zqgf9er0zdmuhyl2

Please note that you must be 18 years of age or older to participate, that you should not participate if you have a history of seizures or seizure disorders, that your participation is voluntary, and you may withdraw your participation at any time without consequence. All of your data will be kept secure and confidential. Because there exists a risk of minor injuries during the welding process, appropriate safety equipment and training will be provided. You will, however, need to wear long pants without any holes and/or frays (i.e., jeans or work pants) and close-toed leather shoes (work boots preferred) to your appointment.

If you have any questions about this study, do not hesitate to contact us, Trent Wells, at (205) 471-1303 or tkw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Regards,

Trent Wells
Graduate Student
Iowa State University

Greg Miller
Professor
Iowa State University
In-class Announcement: Encouragement to Participate in a Welding Skill Performance Study

Hello students,

I have a brief announcement about a study that is about to start here at Iowa State University. It is about welding skill performance, and I am encouraging your participation in this research. This study is being conducted by Trent Wells, under the direction of his major professor, Greg Miller, and is required as part of his doctoral program in the Department of Agricultural Education and Studies.

For your part, you would be completing a short demographics questionnaire and participating in a 60-minute-long welding instruction, practice, and testing session. All welding activities will take place here at the ISU Agricultural Mechanics Teaching Laboratory.

Participation in the study will entitle you to be entered into a drawing to win one of four $40.00 gift cards.

If you wish to participate in this study, you will need to follow the Doodle poll link in the e-mail that you recently received from Trent and select an appointment time that best fits your schedule. Please note that a particular time slot is no longer available if it has already been selected by another individual. If you decide to participate, it is very important that you arrive on time for your scheduled appointment.

Please note that you must be 18 years of age or older to participate, that you should not participate if you have a history of seizures or seizure disorders, that your participation is voluntary, and you may withdraw your participation at any time without consequence. Participation in this study will have no impact on your grade in this course. All of your data will be kept secure and confidential. Because there exists a risk of minor injuries during the welding process, appropriate safety equipment and training will be provided. You will, however, need to wear long pants without any holes or frays (i.e., jeans or work pants) and close-toed leather shoes (work boots preferred) to your appointment. Please invite anyone who you believe may be interested in this study to participate.

If you have any questions about this study, do not hesitate to contact Trent at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Thank you for your time, and have a great day.
Subject: Reminder to Participate in a Welding Skill Performance Study from [TIME] to [TIME] Tomorrow, [DATE]

Hello [NAME],

You have received this message because you are a student enrolled in the [PROGRAM NAME] in the Department of [DEPARTMENT NAME] and have previously indicated that you plan to participate in a welding skill performance study from [TIME] to [TIME] tomorrow, [DATE]. This study is being conducted by me, Trent Wells, under the direction of my major professor, Greg Miller, and is required as part of my doctoral program in the Department of Agricultural Education and Studies.

For your part, you would be completing a short demographics questionnaire and participating in a 60-minute-long welding instruction, practice, and testing session. All welding activities will take place at the ISU Agricultural Mechanics Teaching Laboratory, which is located at:

52097 260th Street, Ames, Iowa 50011

Participation in the designated activities within the study will entitle you to be entered into a drawing to win one of four $40.00 gift cards.

It is very important that you arrive on-time tomorrow. Your participation time will begin promptly at [TIME] and is expected to last until [TIME].

Please note that you must be 18 years of age or older to participate, that you should not participate if you have a history of seizures or seizure disorders, that your participation is voluntary, and you may withdraw your participation at any time without consequence. All of your data will be kept secure and confidential. Because there exists a risk of minor injuries during the welding process, appropriate safety equipment and training will be provided. You will, however, need to wear long pants without any holes and/or frays (i.e., jeans or work pants) and close-toed leather shoes (work boots preferred) to your appointment.

If you have any questions about this study, do not hesitate to contact us, Trent Wells, at (205) 471-1303 or ktrw0004@nastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@nastate.edu.

Regards,

Trent Wells
Graduate Student
Iowa State University

Greg Miller
Professor
Iowa State University
Hello [NAME].

This is Trent Wells. This text message is to remind you that you are scheduled to participate in a welding skill performance study tomorrow, [DATE] from [TIME] to [TIME]. The study will take place at the following address: 52097 260th Street, Ames, Iowa 50011. Please be sure to arrive on-time for your appointment. Have a great day.
INFORMED CONSENT DOCUMENT

Title of Study: Welding Skill Performance Study

Investigators: Trent Wells, primary investigator (PI)/graduate student, and Greg Miller, professor/faculty supervisor

This form describes a research project. It has information to help you decide whether or not you wish to participate. Research studies include only people who choose to take part—your participation is completely voluntary. Please discuss any questions you have about the study or about this form with the project staff before deciding to participate.

Introduction
The purpose of this study is to better understand how welding skills can be developed.

You have been invited to participate in this study. You should not participate if you are under 18 years of age and/or have a history of experiencing seizures or seizure disorders.

Description of Procedures
If you agree to participate, you will:

• Be asked to complete a short demographics questionnaire. This should take approximately 10 minutes.

• Be provided with safety gear, given instruction on how to use welding equipment, asked to use the welding equipment to practice welding, and asked to produce three test welds, one of which will be evaluated by a certified welding inspector (CWI) who is not affiliated with Iowa State University. After equipment use instruction has been given, you will be given time to practice using the welding equipment prior to producing three test welds. The test welds will be done with a different welding machine than the one that you used to practice welding. You will select one test weld to be evaluated by the CWI. This phase of the study should take approximately 40 to 50 minutes.

Risks or Discomforts
While participating in this study you may experience the following risks or discomforts:

• Minor burns from hot metal and/or sparks
• Noise from the welding process
• Bright light given off by the weld arc
• Heat from hot metal

To minimize these risks, you will wear jean/work pants without any holes and/or frays and close-toed leather shoes/boots to the research site and use the provided personal protective equipment (PPE) while at the research site. The provided PPE will include safety glasses, ear plugs, flame-resistant welding gloves, a flame-resistant welding jacket, a welding cap, and a welding helmet/hood. You should not participate if you have a history of seizures or seizure disorders.
Benefits
If you decide to participate in this study, there may be direct benefits to you in the form of receiving free welding skill training. It is hoped that the information gained in this study will benefit society by better understanding how welding skills can be developed.

Costs and Compensation
You will not have any costs from participating in this study. You may possibly be compensated for participating in this study. Your name could be randomly drawn to win a $40.00 gift card. This drawing will occur at the conclusion of the study, and you will be notified via e-mail if your name was selected. You will need to complete a form to receive payment. Please know that payments may be subject to tax withholding requirements, which vary depending upon whether you are a legal resident of the U.S. or another country. If required, taxes will be withheld from the payment you receive.

Participant Rights
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If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3113.

Research Injury
Emergency treatment of any injuries that may occur as a direct result of participation in this research is available at the Iowa State University Thomas B. Thielman Student Health Center and/or referred to Mary Greeley Medical Center or another physician or medical facility at the location of the research activity. Compensation for any injuries will be paid if it is determined under the Iowa Tort Claims Act, Chapter 669 Iowa Code. Claims for compensation should be submitted on approved forms to the State Appeals Board and are available from the Iowa State University Office of Risk Management and Insurance.

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To ensure confidentiality to the extent permitted by law, the following measures will be taken:

- All research activities will be completed by the participants on an individual basis.
- All test welds will be coded to protect the identities of the participants.
• All test welds will be stored in a locked, secure location at the research site.
• All questionnaires will be stored in a locked filing cabinet in the PI's office.
• All electronic data will be stored in a secure, password-protected Cyber folder that is accessible only by the PI and the faculty supervisor.
• No identifiable data will be reported in any publications or presentations that result from this research study.
• De-identified data collected during this study may be shared with other researchers or used for future research studies. We will not obtain additional informed consent from you before sharing the de-identified data.

Questions
You are encouraged to ask questions at any time during this study. For further information about the study, contact Trent Wells, at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gmmiller@iastate.edu.

Consent and Authorization Provisions
Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant's Name (printed) __________________________________________

Participant's Signature __________________ Date __________

Office for Responsible Research
Revised 4/3/2017
Participant ID Code: _____________________________

WELDING SKILL PERFORMANCE STUDY

PARTICIPANT DEMOGRAPHICS QUESTIONNAIRE

1) What is your gender?

_______________________________

2) What is your age?

____ Years

3) Which hand is your dominant hand?

____ Left hand
____ Right hand

4) Please indicate your current academic standing (Check one):

____ Freshman
____ Sophomore
____ Junior
____ Senior
____ Graduate

5) What is your academic major?

_______________________________

6) Have you ever welded before?

____ Yes
____ No

7) If you have welded before, where have you learned how to weld? (Check all that apply)

____ At my family’s farm or business
____ At a farm or business not owned by my family
____ In a facility at my house (e.g., garage, workshop, etc.)
____ In my high school’s Agricultural Education program
____ In my high school’s Industrial Technology program
____ Other location (Please specify) _____________________________

Additional questions on the back side of this document
8) If you have welded before, where have you gotten the opportunity to weld or practice welding? (Check all that apply)

- At my family’s farm or business
- At a farm or business not owned by my family
- In a facility at my house (e.g., garage, workshop, etc.)
- In my high school’s Agricultural Education program
- In my high school’s Industrial Technology program
- Other location (Please specify)

9) If you have welded before, which of the following weld processes have you performed?

- Shielded Metal Arc Welding (SMAW; “Stick Welding”)
- Gas Metal Arc Welding (GMAW; “MIG”, “Wire Welding”)
- Flux Cored Arc Welding (FCAW)
- Submerged Arc Welding (SAW)
- Oxy-fuel Welding (OAW)
- Gas Tungsten Arc Welding (GTAW, “TIG”)

10) If you have welded before, approximately how many hours of experience do you have in each of the following weld processes?

- Shielded Metal Arc Welding (SMAW; “Stick Welding”)
- Gas Metal Arc Welding (GMAW; “MIG”, “Wire Welding”)
- Flux Cored Arc Welding (FCAW)
- Submerged Arc Welding (SAW)
- Oxy-fuel Welding (OAW)
- Gas Tungsten Arc Welding (GTAW, “TIG”)

11) Have you ever used a welding simulation / simulator system (i.e., virtual reality, augmented reality, etc.) before?

- Yes
- No

12) Estimate the average number of hours that you spend per day playing video (e.g., computer, console, mobile, etc.) games.

- Hour(s) per day
<table>
<thead>
<tr>
<th>Test ID:</th>
<th>Participant ID Code:</th>
</tr>
</thead>
</table>

**PERFORMANCE QUALIFICATION CHECKLIST: VISUAL INSPECTION RESULTS**

**AWS D1.1 TABLE 6.1 CRITERIA (STATICALLY-LOADED CONNECTIONS)**

**DIRECTIONS:** Place a checkmark in the blank that best represents the weld’s characteristics.

<table>
<thead>
<tr>
<th>Cracks:</th>
<th>Complete Fusion:</th>
</tr>
</thead>
<tbody>
<tr>
<td>None Present</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Rejected</td>
<td>Rejected</td>
</tr>
</tbody>
</table>

(20) (20) (0) (0)

<table>
<thead>
<tr>
<th>Weld Profile:</th>
<th>Undercut:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meets Requirements</td>
<td>None Present</td>
</tr>
<tr>
<td>Acceptable Below Tolerance</td>
<td>Present Below Tolerance</td>
</tr>
<tr>
<td>Acceptable At Tolerance</td>
<td>Present At Tolerance</td>
</tr>
<tr>
<td>Rejected / Exceeds Tolerance</td>
<td>Present Above / Exceeds Tolerance</td>
</tr>
</tbody>
</table>

(10) (7) (5) (0)

<table>
<thead>
<tr>
<th>Fillet Size (Leg &amp; Throat):</th>
<th>Porosity:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meets Requirements</td>
<td>None Present</td>
</tr>
<tr>
<td>Acceptable Below Tolerance</td>
<td>Present Below Tolerance</td>
</tr>
<tr>
<td>Acceptable At Tolerance</td>
<td>Present At Tolerance</td>
</tr>
<tr>
<td>Rejected / Exceeds Tolerance</td>
<td>Present Above / Exceeds Tolerance</td>
</tr>
</tbody>
</table>

(10) (7) (5) (0)

<table>
<thead>
<tr>
<th>Crater Cross-section:</th>
<th>Total Score:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptable</td>
<td></td>
</tr>
<tr>
<td>Rejected</td>
<td></td>
</tr>
</tbody>
</table>

(20) (0) / 100

Weld Evaluator’s Name (Please Print): ________________________________

Weld Evaluator’s Signature: ________________________________

Date of Inspection: ________________________________

Time of Inspection: ________________________________
Definitions of Terms

Crack: Fracture-type discontinuities that can be readily identified by their sharp tip and high ratio of length and width to the displacement of the opening.

Crater Cross-section: The presence of depressions in the weld cross-section/weld face.

Porosity: A cavity-like discontinuity that forms when gas is entrapped in solidifying weld metal.

Undercut: The melting away of the groove face of a joint at the edge of a layer or bead of weld metal.

Fillet Size: The length of the legs of the triangle inscribed into the cross-section of a completed fillet weld.

Fillet Weld Leg: The distance from the joint root to the toe of the fillet weld.

Fillet Weld Throat: The shortest distance between the weld root and the face of a fillet weld.

Weld Profile: The uniformity of a weld cross-section (i.e., overlap, undercut, etc.).

Complete Fusion: The completeness of the fusion between the weld metal and the base metal.
WELD TRAINING PROTOCOL SCRIPT

Group One (Live Welding Only):

Ten Minutes of Introductions, Informed Consent Letter Reading and Signing, and Demographics Questionnaire Completion

Researcher: Welcome to the Iowa State University Agricultural Mechanics Teaching Laboratory. My name is Trent Wells, and I’ll be working with you today. Please follow me. (Take subject to table at the front of the laboratory area.) Please take a moment to read this informed consent letter and sign it and return it to me if you wish to participate in this study. Afterward, please complete this demographics questionnaire and turn it in to me when you are finished. (Subject completes questionnaire.) Thank you. Now please follow me. (Take subject to welding booth.)

Five Minutes of Live Welding Training

Researcher: You will be using the Miller® XMT® 350 CC/CV Multiprocess Welder to produce tee welds that look like this. (Show subject a completed 2F horizontal position tee weld.) The machine is already set and ready to go. The settings are as follows: 21.0 volts using a 90/10 argon/carbon dioxide (CO₂) gas mixture at 370” per minute (wire feed speed). The material that you will be welding is ¼”-thick mild steel. Please don your welding helmet, welding jacket, safety glasses, welding cap, welding gloves, and ear plugs. (All welding personal protective equipment (PPE) will be provided by the researcher.) Before welding, I will show you how to position yourself as you prepare to complete this tee weld. You will need to hold your welding gun at a work angle of 40 to 45 degrees and a travel angle of 10 to 15 degrees. (Show positioning.) Once you are in position and ready to weld, squeeze and hold the trigger and begin pushing the molten puddle into the joint. When you are ready to stop welding, simply release the trigger. If you have an excessive amount of wire sticking out of the end of the welding gun, use a pair of welding pliers (Show subject a pair of welding pliers) to cut the excess off (Show subject how to cut wire with welding pliers). I will now demonstrate how to use this machine to successfully complete this weld. First, however, we need to tack these two pieces of metal together. To tack weld these two pieces into a tee shape, use a magnet to hold the two pieces at a 90 degree angle and quickly do a small weld. Please be sure to say, “Cover!” before you weld so that anyone around will know not to look this way. Cover! (Demonstrate tack welds) After you complete the tack welds, be sure to remove the magnet to avoid a fire. Did you see how I did that? Do you need to see it again? Let’s move on to the weld demonstration. (Complete a 2F horizontal position tee weld.) Were you able to see to see how I did that? Would you like for me to demonstrate the weld again? You will be allowed as much metal as you need in order to practice, so you can use this entire stack if you need to. Please be sure to always wear your safety equipment when welding. If you need to see what a good weld should look like and what causes weld imperfections, please have a look at this weld quality poster between welds (Show subject the weld quality poster.) The fillet size requirement is 1/4”, the keyhole piece on the vertical piece of steel cannot be included in the weldment, and the welds must be at least 4” long and cannot include the rounded corners of the vertical piece of steel. You will practice welding this position for 30 minutes, and then you’ll have five minutes to complete three welds and
choose the best one to serve as a test weld for data collection purposes. You will not use the same welding booth and Miller® XMT® 350 CC/CV Multiprocess Welder for the testing phase that you used for the training and practice phases. Do you have any questions? If you need anything, please call for me. I’ll be waiting across the room. Good luck, and thank you.

**Thirty Minutes of Practice**

Subject welds for 30 minutes. Assistance will be given if needed.

**Five Minutes of Testing**

Researcher: Now that you’ve had 30 total minutes of practice, I want you to move to this other welding booth and use the Miller® XMT® 350 CC/CV Multiprocess Welder to complete three welds and choose your best one to serve as a test weld that will be used for data collection purposes. The fillet size requirement is 1/4”, the keyhole piece on the vertical piece of steel cannot be included in the weldment, and the welds must be at least 4” long and cannot include the rounded corners of the vertical piece of steel. After you complete these welds, please cool each one in the bucket of water near your booth and set the best weld on the large blue steel table. Afterward, please clean your work area and place all steel that you used to practice on in the green metal bin in the back of the lab area. Once you have set your test weld aside and have cleaned your work areas, you may remove your welding PPE and set it on the gray table at the front of the lab area. Good luck, and thank you.

Subject completes and cools the welds, selects the best weld and places it one the large blue table, cleans the welding area, and places all welding PPE in the proper location. After it is cool to the touch, the test weld will be coded based on the subject’s participant and group numbers (i.e., 004-03, etc.) and placed in a storage container away from the work area for future evaluation.

Researcher: Thank you for participating in this study. I encourage you to encourage others to participate in this study as well. Have a great day.
WELD TRAINING PROTOCOL SCRIPT

Group Two (Virtual Welding Only):

Ten Minutes of Introductions, Informed Consent Letter Reading and Signing, and Demographics Questionnaire Completion

Researcher: Welcome to the Iowa State University Agricultural Mechanics Teaching Laboratory. My name is Trent Wells, and I’ll be working with you today. Please follow me. (Take subject to table at the front of the laboratory area.) Please take a moment to read this informed consent letter and sign it and return it to me if you wish to participate in this study. Afterward, please complete this demographics questionnaire and turn it in to me when you are finished. (Subject completes questionnaire.) Thank you. Now please follow me. (Take subject to Lincoln Electric® VRTEX® 360 station.)

Five Minutes of Virtual Welding Training

Researcher: You will be using a virtual welding machine to practice producing tee welds. You will use the Lincoln Electric® VRTEX® 360 to hone your skills. (Show subject a completed 2F horizontal position tee weld.) The machine is already set and ready to go. The settings are as follows: 21.0 volts using a 90/10 argon/carbon dioxide (CO₂) gas mixture at 370” per minute (wire feed speed). The material that you will be welding is set as ¼”-thick mild steel. Please don your welding jacket, safety glasses, welding cap, welding gloves, and ear plugs. (All welding personal protective equipment (PPE) will be provided by the researcher.) Your welding helmet will be the virtual reality helmet that’s attached to the machine. It allows you to see the virtual world, so you can move your head around and see what’s in this reality. Look at the screen to see what I can see. Before using the Lincoln Electric® VRTEX® 360, I will show you how to position yourself as you prepare to complete this tee weld. You will need to hold your welding gun at a work angle of 40 to 45 degrees and a travel angle of 10 to 15 degrees. (Show positioning.) Once you are in position and ready to weld, squeeze and hold the trigger and begin pushing the molten puddle into the joint. When you are ready to stop welding, simply release the trigger. I will now demonstrate how to use this machine to successfully complete this virtual weld. (Complete a virtual 2F horizontal position tee weld.) Were you able to see to see how I did that? Would you like for me to demonstrate the weld again? After you complete each weld, push this blue button to end the weld and push the white arrow to view your score. On this screen, you will be able to see what areas of your technique need improvement. Please be sure to always wear your safety equipment when welding. You will practice welding this position for 30 minutes, and then I’ll show you how to use the Miller® XMT® 350 CC/CV Multiprocess Welder to complete three welds and choose the best one to serve as a test weld for data collection purposes. You will not use the same welding booth and Miller® XMT® 350 CC/CV Multiprocess Welder for the testing phase that you used for the training phase. Do you have any questions? If you need anything, please call for me. I’ll be waiting across the room. Good luck, and thank you.

Thirty Minutes of Practice

Subject virtual welds for 30 minutes. Assistance will be given if needed.
Five Minutes of Live Welding Training

Researcher: You will be using a Miller® XMT® 350 CC/CV Multiprocess Welder to produce tee welds that look like this. (Show subject a completed 2F horizontal position tee weld.) The machine is already set and ready to go. The settings are as follows: 21.0 volts using a 90/10 argon/carbon dioxide (CO₂) gas mixture at 370” per minute (wire feed speed). The material that you will be welding is \( \frac{3}{8}” \)-thick mild steel. Please don your welding helmet, welding jacket, safety glasses, welding cap, welding gloves, and ear plugs. (All welding personal protective equipment (PPE) will be provided by the researcher.) Before welding, I will show you how to position yourself as you prepare to complete this tee weld. You will need to hold your welding gun at a work angle of 40 to 45 degrees and a travel angle of 10 to 15 degrees. (Show positioning.) Once you are in position and ready to weld, squeeze and hold the trigger and begin pushing the molten puddle into the joint. When you are ready to stop welding, simply release the trigger. If you have an excessive amount of wire sticking out of the end of the welding gun, use a pair of welding pliers (Show subject a pair of welding pliers) to cut the excess off (Show subject how to cut wire with welding pliers). I will now demonstrate how to use this machine to successfully complete this weld. First, however, we need to tack these two pieces of metal together. To tack weld these two pieces into a tee shape, use a magnet to hold the two pieces at a 90 degree angle and quickly do a small weld. Please be sure to say, “Cover!” before you weld so that anyone around will know not to look this way. Cover! (Demonstrate tack welds) After you complete the tack welds, be sure to remove the magnet to avoid a fire. Did you see how I did that? Do you need to see it again? Let’s move on to the weld demonstration. (Complete a 2F horizontal position tee weld.) Were you able to see to see how I did that? Would you like for me to demonstrate the weld again? Please be sure to always wear your safety equipment when welding. If you need to see what a good weld should look like and what causes weld imperfections, please have a look at this weld quality poster between welds (Show subject the weld quality poster.) The fillet size requirement is \( 1/4” \), the keyhole piece on the vertical piece of steel cannot be included in the weldment, and the welds must be at least \( 4” \) long and cannot include the rounded corners of the vertical piece of steel. You have five minutes to complete three welds and choose the one that will serve as your test weld for data collection purposes. You will not use the same welding booth and Miller® XMT® 350 CC/CV Multiprocess Welder for the testing phase that you used for the training phase. Do you have any questions? If you need anything, please call for me. I’ll be waiting across the room. Good luck, and thank you.

Five Minutes of Testing

Researcher: After you complete these welds, please cool each one in the bucket of water near your booth and set the best weld on the large blue steel table. Afterward, please clean your work area and place all steel that you used to practice on in the green metal bin in the back of the lab area. Once you have set your best test weld aside and have cleaned your work area, you may remove your welding PPE and set it on the gray table at the front of the lab area. Good luck, and thank you.

Subject completes and cools the welds, selects the best weld and places it on the large blue table, cleans the welding area, and places all welding PPE in the proper location. After it is cool to the touch, the test weld will be coded based on the subject’s participant and group numbers.
(i.e., 004-03, etc.) and placed in a storage container away from the work area for future evaluation.

*Researcher: Thank you for participating in this study. I encourage you to encourage others to participate in this study as well. Have a great day.*
WELD TRAINING PROTOCOL SCRIPT

Group Three (Live Welding then Virtual Welding):

Ten Minutes of Introductions, Informed Consent Letter Reading and Signing, and Demographics Questionnaire Completion

Researcher: Welcome to the Iowa State University Agricultural Mechanics Teaching Laboratory. My name is Trent Wells, and I’ll be working with you today. Please follow me. (Take subject to table at the front of the laboratory area.) Please take a moment to read this informed consent letter and sign it and return it to me if you wish to participate in this study. Afterward, please complete this demographics questionnaire and turn it in to me when you are finished. (Subject completes questionnaire.) Thank you. Now please follow me. (Take subject to welding booth.)

Five Minutes of Live Welding Training

Researcher: You will be using a Miller® XMT® 350 CC/CV Multiprocess Welder welding machine to produce tee welds that look like this. (Show subject a completed 2F horizontal position tee weld.) The machine is already set and ready to go. The settings are as follows: 21.0 volts using a 90/10 argon/carbon dioxide (CO₂) gas mixture at 370” per minute (wire feed speed). The material that you will be welding is ¼”-thick mild steel. Please don your welding helmet, welding jacket, safety glasses, welding cap, welding gloves, and ear plugs. (All welding personal protective equipment (PPE) will be provided by the researcher.) Before welding, I will show you how to position yourself as you prepare to complete this tee weld. You will need to hold your welding gun at a work angle of 40 to 45 degrees and a travel angle of 10 to 15 degrees. (Show positioning.) Once you are in position and ready to weld, squeeze and hold the trigger and begin pushing the molten puddle into the joint. When you are ready to stop welding, simply release the trigger. If you have an excessive amount of wire sticking out of the end of the welding gun, use a pair of welding pliers (Show subject a pair of welding pliers) to cut the excess off (Show subject how to cut wire with welding pliers). I will now demonstrate how to use this machine to successfully complete this weld. First, however, we need to tack these two pieces of metal together. To tack weld these two pieces into a tee shape, use a magnet to hold the two pieces at a 90 degree angle and quickly do a small weld. Please be sure to say, “Cover!” before you weld so that anyone around will know not to look this way. Cover! (Demonstrate tack welds) After you complete the tack welds, be sure to remove the magnet to avoid a fire. Did you see how I did that? Do you need to see it again? Let’s move on to the weld demonstration. (Complete a 2F horizontal position tee weld.) Were you able to see to see how I did that? Would you like for me to demonstrate the weld again? You will be allowed as much metal as you need in order to practice, so you can use this entire stack if you need to. Please be sure to always wear your safety equipment when welding. If you need to see what a good weld should look like and what causes weld imperfections, please have a look at this weld quality poster between welds (Show subject the weld quality poster.) The fillet size requirement is 1/4”, the keyhole piece on the vertical piece of steel cannot be included in the weldment, and the welds must be at least 4” long and cannot include the rounded corners of the vertical piece of steel. I will practice welding this position for 15 minutes, and then you’ll receive five minutes of training on the Lincoln Electric®
VRTEX® 360 and have 15 minutes to practice virtual welding. Afterward, you’ll have five minutes to use the Miller® XMT® 350 CC/CV Multiprocess Welder to complete three welds and choose the best one to serve as a test weld for data collection purposes. You will not use the same welding booth and Miller® XMT® 350 CC/CV Multiprocess Welder for the testing phase that you used for the training and practices phases. Do you have any questions? If you need anything, please call for me. I’ll be waiting across the room. Good luck, and thank you.

**Fifteen Minutes of Practice**

Subject welds for 15 minutes. Assistance will be given if needed.

**Five Minutes of Virtual Welding Training**

Researcher: You will be using a virtual welding machine to practice producing tee welds. You will use the Lincoln Electric® VRTEX® 360 to hone your skills. (Show subject a completed 2F horizontal position tee weld.) The machine is already set and ready to go. The settings are as follows: 21.0 volts using a 90/10 argon/carbon dioxide (CO2) gas mixture at 370” per minute (wire feed speed). The material that you will be welding is set as ¼”-thick mild steel. Please don your welding jacket, safety glasses, welding cap, welding gloves, and ear plugs. (All welding personal protective equipment (PPE) will be provided by the researcher.) Your welding helmet will be the virtual reality helmet that’s attached to the machine. It allows you to see the virtual world, so you can move your head around and see what’s in this reality. Look at the screen to see what I can see. Before using the Lincoln Electric® VRTEX® 360, I will show you how to position yourself as you prepare to complete this tee weld. You will need to hold your welding gun at a work angle of 40 to 45 degrees and a travel angle of 10 to 15 degrees. (Show positioning.) Once you are in position and ready to weld, squeeze and hold the trigger and begin pushing the molten puddle into the joint. When you are ready to stop welding, simply release the trigger. I will now demonstrate how to use this machine to successfully complete this virtual weld. (Complete a virtual 2F horizontal position tee weld.) Were you able to see to see how I did that? Would you like for me to demonstrate the weld again? After you complete each weld, push this blue button to end the weld and push the white arrow to view your score. On this screen, you will be able to see what areas of your technique need improvement. Please be sure to always wear your safety equipment when welding. You will practice welding this position for 15 minutes, and then you’ll use the Miller® XMT® 350 CC/CV Multiprocess Welder to complete three welds and choose the best one to serve as a test weld for data collection purposes. You will not use the same welding booth and Miller® XMT® 350 CC/CV Multiprocess Welder for the testing phase that you used for the training and practice phases. Do you have any questions? If you need anything, please call for me. I’ll be waiting across the room. Good luck, and thank you.

**Fifteen Minutes of Practice**

Subject virtual welds for 15 minutes. Assistance will be given if needed.
Five Minutes of Testing

Researcher: Now that you’ve had 30 total minutes of practice, I want you to use the Miller® XMT® 350 CC/CV Multiprocess Welder to complete three welds and choose your best one to serve as a test weld that will be used for data collection purposes. The fillet size requirement is 1/4”, the keyhole piece on the vertical piece of steel cannot be included in the weldment, and the welds must be at least 4” long and cannot include the rounded corners of the vertical piece of steel. After you complete these welds, please cool each one in the bucket of water near your booth and set the best weld on the large blue steel table. Afterward, please clean your work area and place all steel that you used to practice on in the green metal bin in the back of the lab area. Once you have set your test weld aside and have cleaned your work area, you may remove your welding PPE and set it on the gray table at the front of the lab area. Good luck, and thank you.

Subject completes and cools the welds, selects the best weld and places it one the large blue table, cleans the welding area, and places all welding PPE in the proper location. After it is cool to the touch, the test weld will be coded based on the subject’s participant and group numbers (i.e., 004-03, etc.) and placed in a storage container away from the work area for future evaluation.

Researcher: Thank you for participating in this study. I encourage you to encourage others to participate in this study as well. Have a great day.
WELD TRAINING PROTOCOL SCRIPT

Group Four (Virtual Welding then Live Welding):

Ten Minutes of Introductions, Informed Consent Letter Reading and Signing, and Demographics Questionnaire Completion

Researcher: Welcome to the Iowa State University Agricultural Mechanics Teaching Laboratory. My name is Trent Wells, and I’ll be working with you today. Please follow me. (Take subject to table at the front of the laboratory area.) Please take a moment to read this informed consent letter and sign it and return it to me if you wish to participate in this study. Afterward, please complete this demographics questionnaire and turn it in to me when you are finished. (Subject completes questionnaire.) Thank you. Now please follow me. (Take subject to Lincoln Electric® VRTEX® 360 station.)

Five Minutes of Virtual Welding Training

Researcher: You will be using a virtual welding machine to practice producing tee welds. You will use the Lincoln Electric® VRTEX® 360 to hone your skills. (Show subject a completed 2F horizontal position tee weld.) The machine is already set and ready to go. The settings are as follows: 21.0 volts using a 90/10 argon/carbon dioxide (CO₂) gas mixture at 370” per minute (wire feed speed). The material that you will be welding is set as ¼”-thick mild steel. Please don your welding jacket, safety glasses, welding cap, welding gloves, and ear plugs. (All welding personal protective equipment (PPE) will be provided by the researcher.) Your welding helmet will be the virtual reality helmet that’s attached to the machine. It allows you to see the virtual world, so you can move your head around and see what’s in this reality. Look at the screen to see what I can see. Before using the Lincoln Electric® VRTEX® 360, I will show you how to position yourself as you prepare to complete this tee weld. You will need to hold your welding gun at a work angle of 40 to 45 degrees and a travel angle of 10 to 15 degrees. (Show positioning.) Once you are in position and ready to weld, squeeze and hold the trigger and begin pushing the molten puddle into the joint. When you are ready to stop welding, simply release the trigger. I will now demonstrate how to use this machine to successfully complete this virtual weld. (Complete a virtual 2F horizontal position tee weld.) Were you able to see to see how I did that? Would you like for me to demonstrate the weld again? After you complete each weld, push this blue button to end the weld and push the white arrow to view your score. On this screen, you will be able to see what areas of your technique need improvement. Please be sure to always wear your safety equipment when welding. You will practice welding this position for 15 minutes, and then you’ll receive five minutes of training on the Miller® XMT® 350 CC/CV Multiprocess Welder and have 15 minutes to practice live welding. Afterward, you’ll have five minutes to use the Miller® XMT® 350 CC/CV Multiprocess Welder to complete three welds and choose the best one to serve as a test weld for data collection purposes. You will not use the same welding booth and Miller® XMT® 350 CC/CV Multiprocess Welder for the testing phase that you used for the training and practice phases. Do you have any questions? If you need anything, please call for me. I’ll be waiting across the room. Good luck, and thank you.
Fifteen Minutes of Practice

Subject virtual welds for 15 minutes. Assistance will be given if needed.

Five Minutes of Live Welding Training

Researcher: You will be using a Miller® XMT® 350 CC/CV Multiprocess Welder to produce tee welds that look like this. (Show subject a completed 2F horizontal position tee weld.) The machine is already set and ready to go. The settings are as follows: 21.0 volts using a 90/10 argon/carbon dioxide (CO₂) gas mixture at 370” per minute (wire feed speed). The material that you will be welding is ¼”-thick mild steel. Please don your welding helmet, welding jacket, safety glasses, welding cap, welding gloves, and ear plugs. (All welding personal protective equipment (PPE) will be provided by the researcher.) Before welding, I will show you how to position yourself as you prepare to complete this tee weld. You will need to hold your welding gun at a work angle of 40 to 45 degrees and a travel angle of 10 to 15 degrees. (Show positioning.) Once you are in position and ready to weld, squeeze and hold the trigger and begin pushing the molten puddle into the joint. When you are ready to stop welding, simply release the trigger. If you have an excessive amount of wire sticking out of the end of the welding gun, use a pair of welding pliers (Show subject a pair of welding pliers) to cut the excess off (Show subject how to cut wire with welding pliers). I will now demonstrate how to use this machine to successfully complete this weld. First, however, we need to tack these two pieces of metal together. To tack weld these two pieces into a tee shape, use a magnet to hold the two pieces at a 90 degree angle and quickly do a small weld. Please be sure to say, “Cover!” before you weld so that anyone around will know not to look this way. Cover! (Demonstrate tack welds) After you complete the tack welds, be sure to remove the magnet to avoid a fire. Did you see how I did that? Do you need to see it again? Let’s move on to the weld demonstration. (Complete a 2F horizontal position tee weld.) Were you able to see to see how I did that? Would you like for me to demonstrate the weld again? You will be allowed as much metal as you need in order to practice, so you can use this entire stack if you need to. Please be sure to always wear your safety equipment when welding. If you need to see what a good weld should look like and what causes weld imperfections, please have a look at this weld quality poster between welds (Show subject the weld quality poster.) The fillet size requirement is 1/4”, the keyhole piece on the vertical piece of steel cannot be included in the weldment, and the welds must be at least 4” long and cannot include the rounded corners of the vertical piece of steel. You will practice welding this position for 15 minutes, and then you’ll have five minutes to use the Miller® XMT® 350 CC/CV Multiprocess Welder to complete three welds and select the best one to serve as a test weld for data collection purposes. You will not use the same welding booth and Miller® XMT® 350 CC/CV Multiprocess Welder for the testing phase that you used for the training and practice phases. Do you have any questions? If you need anything, please call for me. I’ll be waiting across the room. Good luck, and thank you.

Fifteen Minutes of Practice

Subject welds for 15 minutes. Assistance will be given if needed.
Five Minutes of Testing

Researcher: Now that you’ve had 30 total minutes of practice, I want you to move to this other welding booth and use the Miller® XMT® 350 CC/CV Multiprocess Welder to complete three welds and choose your best one to serve as a test weld that will be used for data collection purposes. The fillet size requirement is 1/4”, the keyhole piece on the vertical piece of steel cannot be included in the weldment, and the welds must be at least 4” long and cannot include the rounded corners of the vertical piece of steel. After you complete these welds, please cool each one in the bucket of water near your booth and set the best weld on the large blue steel table. Afterward, please clean your work area and place all steel that you used to practice on in the green metal bin in the back of the lab area. Once you have set your test weld aside and have cleaned your work area, you may remove your welding PPE and set it on the gray table at the front of the lab area. Good luck, and thank you.

Subject completes and cools the welds, selects the best weld and places it one the large blue table, cleans the welding area, and places all welding PPE in the proper location. After it is cool to the touch, the test weld will be coded based on the subject’s participant and group numbers (i.e., 004-03, etc.) and placed in a storage container away from the work area for future evaluation.

Researcher: Thank you for participating in this study. I encourage you to encourage others to participate in this study as well. Have a great day.
Subject: Debriefing from Recent Participation in a Welding Skill Performance Pilot Study/Formal Study

Hello [NAME],

You have received this message because you recently participated in a welding skill performance pilot study/study that was conducted by me, Trent Wells, under the direction of my major professor, Greg Miller, and was required as part of my doctoral program in the Department of Agricultural Education and Studies.

I wish to thank you for your participation, as well as inform you about some minor details of the study that were withheld from you. While you were assigned to a particular training protocol during the pilot study/study, there were, in fact, four different training protocols used during the pilot study/study.

The reason that you were not informed about the use of the four different training protocols was that your attitude toward the training protocol that you experienced may have affected how you performed if you knew that other participants were receiving different training protocols.

Please note that if you participated in one of the three training protocols that used the virtual reality welding system, the virtual weld data collected during the pilot study/study will be retained in a de-identified manner for future research purposes.

If you have any questions about this study, do not hesitate to contact us, Trent Wells, at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu. The Iowa State University Institutional Review Board (IRB) can be contacted with any questions about this study, as well. The IRB office can be reached at (515) 294-4566 or irb@iastate.edu.

Once again, thank you very much for participating in this pilot study/study.

Regards,

Trent Wells
Graduate Student
Iowa State University

Greg Miller
Professor
Iowa State University
Subject: Welding Skill Performance Pilot Study Gift Card

Hello [NAME],

You have received this message because you recently participated in a pilot study about welding skill performance. I am pleased to inform you that your name was randomly selected to receive a $40.00 gift card for your participation.

To claim your gift card, please e-mail Trent Wells at ktw0004@iastate.edu to schedule a pick-up time. The gift card should be picked up at the following location: 223C Curtiss Hall.

Per Iowa State University regulations, you will also need to complete and return the form in the link below:

http://www.controller.iastate.edu/controller/rprfless.pdf

If you have any questions about this gift card or the process to obtain it, do not hesitate to contact us, Trent Wells, at (205) 471-1303 or ktw0004@iastate.edu, or Greg Miller, at (515) 294-2583 or gsmiller@iastate.edu.

Regards,

Trent Wells  Greg Miller
Graduate Student  Professor
Iowa State University  Iowa State University
Subject: Welding Skill Performance Study Gift Card

Hello [NAME],

You have received this message because you recently participated in a study about welding skill performance. I am pleased to inform you that your name was randomly selected to receive a $40.00 gift card for your participation.

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Regards,

Trent Wells
Graduate Student
Iowa State University

Greg Miller
Professor
Iowa State University
APPENDIX C

ROBERTS AND BALL’S MODEL REPRINTED PERMISSION

Kate Shoulders

to me

Trent,

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Kate

Kate Shoulders, Ph.D.
Associate Professor
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**APPENDIX D**

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The Integration of Virtual Reality Technology into Agricultural Education

**Institution name**

Iowa State University

**Expected presentation date**

May 2019

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**FISHBEIN AND AJZEN’S MODEL REPRINTED PERMISSION**

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